

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edited by

LEWIS STEPHEN PILCHER, M.D., LL.D.

of New York

With the Collaboration of

SIR WILLIAM MACEWEN, M.D., LL.D.

of Glasgow

W. H. CLAYTON GREENE, F.R.C.S.

of London

RUPTURED SPLEENS. SPONTANEOUS AND SUBCUTANEOUS	
JOHN F. CONNORS, M.D.	NEW YORK
SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN, WITH ABSTRACT OF CASES REPORTED BETWEEN 1842 AND 1921	
WILLIAM E. LEIGHTON, M.D.	ST. LOUIS
SURGERY OF CYSTS OF THE SPLEEN	
ROYALS H. FOWLER, M.D.	BROOKLYN, N. Y.
TECHNIC OF NERVE SURGERY	
K. WINFIELD NEY, M.D.	NEW YORK
THE SURGERY OF INFANTILE PARALYSIS	
J. TORRANCE RUGH, M.D.	PHILADELPHIA
FRACTURE OF THE SKULL IN CHILDREN	
JOHN J. MOOREHEAD, M.D. AND WALTER WHEELER, M.D.	NEW YORK
THE VALUE OF DAKIN'S SOLUTION IN THE TREATMENT OF THORACIC EMPYEMA	
ABRAHAM O. WILKINSKY, M.D.	NEW YORK
PRIMARY CLOSURE OF THE URETER AND RENAL PELVIS AFTER NEPHROLITHOTOMY	
LE GRAND GURDEV, M.D.	COLUMBIA, S. C.
URETERO-URETERAL ANASTOMOSIS	
J. D. McEACHERN, M.D.	WINNIPEG
DIVERTICULA OF THE JEJUNUM	
HUGH N. MACKECHNIE, A.B., M.D., C.M.	CHICAGO
TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY	104
STATED MEETING HELD MARCH 7, 1921	
TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY	120
STATED MEETING HELD MARCH 9, 1921	
CORRESPONDENCE	127

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RUPTURED SPLEENS. SPONTANEOUS AND SUBCUTANEOUS*

By JOHN F. CONNORS, M.D.

OF NEW YORK, N. Y.

FROM the location and the anatomic relations of the spleen it would seem that this organ was well protected from external injury, but upon reviewing the literature one is struck by the number of subcutaneous ruptures reported. In some instances the injury causing the rupture has been very slight. A. Murat Willis¹ reports four cases from an apparently simple injury. Stubenrauch² and Lilienfeld³ each report a case of ruptured spleen caused by a fall from a bicycle. Bessel Hagen,⁴ in 1900, reported thirty-seven cases of splenectomy for trauma with twenty recoveries and seventeen deaths. In 1908 G. B. Johnson⁵ added one hundred and thirteen, with seventy-nine recoveries and thirty-four deaths. Lotsch,⁶ in 1908, reported one hundred and thirty-eight with a mortality of 37.7 per cent. Planson,⁷ in 1909, compiled one hundred and forty splenectomies with a mortality of 37.1 per cent. These reports make it appear that splenectomy for rupture is far from uncommon.

The first successful case of this kind, according to Bier,⁸ was done by Riegues in Breslau in 1892. The operation for splenectomy was first performed by Zaccarrelli in 1549, for a malarial spleen, the patient being a woman twenty-four years old, who recovered.

The spleen is the largest of the ductless glands and it seems that little is known of its function. W. J. Mayo⁹ says that there is a fascination about the study of the spleen. Pathology and experimental medicine have contributed little to our knowledge of the organ. As the spleen has no internal or external secretions, the results of its actions cannot be directly studied. We know that the removal of the normal spleen rendered necessary by trauma, etc., introduces no serious bodily changes. Most physiologists believe that the spleen has the power to destroy red blood-cells. This theory is supported by the following facts according to Mayo:¹⁰

(a) The presence in the spleen of red blood-cells in various stages of disintegration.

(b) The presence in the spleen of large amœboid cells which contain broken-down red blood-cells.

(c) The abundance of organic compounds, rich in iron, probably derived from red blood-cells which have been digested.

(d) The fact that after splenectomy the lymphatic and hæmolymphatic

* Read before the New York Surgical Society, March 23, 1921.

glands become hyperplastic and even increase in number and possess an augmented ability to devour erythrocytes.

Pearce,¹¹ who has made a very exhaustive study of the blood, concludes that the spleen controls and regulates blood destruction. In attempting to explain the anæmia following splenectomy, a close study was made of the liver and the lymph-nodes. An increase in the endothelial cells of the lymphatic glands which were phagocytic for red cells was the result. It was suggested that the lymphatics and possibly the liver compensated in some measure for the loss of splenic function. Ascher¹² has shown that the spleen contains a substance which is but slightly hæmolytic when acting alone, but when acting in combination with a liver extract forms a very powerful hæmolytic agent. Halliburton¹³ claims that the spleen aids in the formation of leucocytes, because he found a greater number of white blood-corpuscles in the splenic vein than in the artery. It is thought that during digestion the spleen acts as a reservoir for the portal system, inasmuch as after a meal the spleen begins to enlarge and reaches its maximum in a few hours.

This point is worthy of consideration as a factor for splenic rupture, and upon a study of the histories it will be observed that in perhaps the majority of cases the ruptures have occurred at or near the point of maximum enlargement.

The spleen is always enlarged in infectious diseases, but little is known of the significance of this condition. J. Collins Warren¹⁴ explains this fact by saying that the spleen is an active agent in the struggle of the body against infections. Whatever the function of the spleen may be, it does not seem to be essential to human life, and some cases have been reported in which it was congenitally absent. On the contrary, Danielsen¹⁵ points out that it is a mistake to consider that the organ can be dispensed with easily. He says that it should be kept in mind that immediate injurious sequelæ have been known to follow its extirpation, such as fatal gastric hemorrhage, enlargement of the thyroid gland and the lymphatic apparatus, indicating that it is by no means a matter of indifference to remove the entire spleen. Wherever practical, resection rather than splenectomy is recommended.

Morris and Bullock,¹⁶ after experimenting with dogs, arrived at the following conclusions: In the absence of infection dogs without spleens get along fairly well, but the reverse is the case where the organism is put to the strain of resisting acute bacterial invasion. If, as we may reasonably suppose, the physiological processes in mammals are similar, it is not improbable that the human body deprived of its spleen shows a similar susceptibility to infection. On the other hand, Michelsen¹⁷ says that the changes in the blood picture following splenectomy must not be exclusively interpreted as reaction phenomena of the organism to the loss of the spleen, for similar conditions are often met with after laparotomies and almost invariably after severe hemorrhage.

The most important changes in the cases of splenectomy for trauma have occurred in the blood, and are more marked than in cases in which the spleen has been removed for disease. Jerome Myers,¹⁸ J. H. Musser, Jr.,¹⁹ Roughton

RUPTURED SPLEENS

and Legg,²⁰ Moro,²¹ Baur,²² Brunzel,²³ Miller,²⁴ Planson,²⁵ Alivisator,²⁶ Lotsch,²⁷ Hubbard,²⁸ and many others have made an exhaustive study of the blood changes following splenectomy, and the most important are as follows: There is an increase in the leucocytes, characterized by a relative increase in the mononuclears. The erythrocytes decrease in number, but gradually increase with the increase in the percentage of hæmoglobin.

It has been observed that a moderate eosinophilia occurs some months after the operation and may persist for a considerable length of time.

Herczel²⁹ and others, in attempting to explain fever following splenectomy, say that if the blood-vessels of the spleen are carefully ligated and injury to the pancreas guarded against, the febrile phenomena will not occur. In the discussion before the surgical section of the Budapest Medical Society, similar experiences were reported by Zimmermann³⁰ from the surgical clinics of Professor Dollinger. I have diligently searched the very abundant literature in an effort to find an explanation of the severe infections of the abdominal walls which have occurred in three of our cases, but have been unsuccessful. These infections persisted for weeks, and resulted in ventral hernias.

Subcutaneous ruptures are caused by contusions, blows, and falls. In four of my six cases the patients had been run down by wagons. In another a child fell about six feet, striking its head and hyperflexed the body, falling backward. Another was caused by the collision of a bicycle and a motorcycle. The diagnosis of ruptured spleen is many times not made until the time of operation. I may add that in cases giving a history of having been run down by wagons, and the body run over from left to right, we have, in the presence of other symptoms, the right to surmise that the spleen is the organ affected, either alone or in conjunction with some other intraabdominal viscus. The pain, radiating to the left shoulder, described by so many authors, has never come to my attention. The chief symptoms which we found in all our cases were abdominal distention, and tenderness which was most marked on the left side. The cases were all in extreme shock and had signs of internal hemorrhage. The temperature was always below normal, the pulse rapid and weak. There is but one treatment for these cases, in my opinion, and that is immediate operation. Berger reports 220 unoperated cases with a mortality of 92.3 per cent.

I cannot agree with Auveay and Vauverts³¹ who advise resection of the costal border, for I believe that there is sufficient room with the abdominal incision. Resection of the costal border necessitates a longer operation, and splenectomy should be done as quickly as possible.

It is apparent that our results in these operations are steadily improving, for Vorwerck,³² in 1900, reports nine cases with three deaths, and from the clinic of Trendelenberg, in 1909, seven cases with but one death. I attribute these good results to the use of direct blood transfusion which is being resorted to more frequently. Theis and Henschen³³ recommend the re-infusion of the blood found in the abdominal cavity. I cannot agree with

this, for I feel that a great deal of this blood finds its way back into the circulation.

The reports of Faltin and Stubenrauch as quoted by Michelsen are very interesting. They claim that in many instances the scattered splenic tissue left in the body is capable very soon of replacing the excised organ. Both of these men found at the time of second laparotomies, one and six years respectively after splenectomy, that the peritoneum of these patients was covered with numerous nodules, showing microscopically the characteristics of splenic tissue which had certainly not been present when the spleen was extirpated. Very similar observations were made by Guerrini upon a dog after experimental splenectomy. Such findings certainly suggest that small accessory spleens occasionally undergo hypertrophy and functionate in the place of the missing main organ. It is desirable that such hyperplastic accessory spleens be looked for in the future, in autopsies which are performed a considerable time after splenectomy. Doctor Willis, from his experimental work on dogs and from his observations on human cases, is satisfied that the cause of death in some cases is due to the non-existence of supernumerary spleens. This was also suggested by Dr. E. H. Oschner.

CASE I.—L. G., aged nine years. Family and previous history, irrelevant.

Present History.—While roller-skating, boy fell on the street and two wheels of an empty express wagon drawn by a horse passed over his body. On admission temperature was 98°, pulse 134, and respirations 32.

Physical Examination.—Well-nourished boy about nine years old, conscious and rational, looks very ill and appears to be suffering great pain. Chest, clear; heart, no murmurs or enlargement; pulse very rapid and weak. Abdomen, tympanitic anteriorly, and tender throughout, most marked on the left side. Liver, kidneys and spleen not palpable. Abrasions on the back.

Blood count on admission: Leucocytes, 17,000; polynuclears, 65 per cent.

A diagnosis of ruptured intestine was made. On operation the spleen was found to be ruptured in several places and was removed. From the beginning this child ran a temperature ranging from 100° to 102°, in spite of which he appeared to be doing well. On the fourteenth day following operation he developed a pleurisy on the left side, and on the following day 300 c.c. of a clear serous fluid, which showed staphylococcus, was removed. Following the removal of this fluid he made an uneventful recovery. On September 23rd, five days after his operation, the blood count was as follows: Leucocytes, 14,500; red blood-cells, 3,500,500; hæmoglobin, 70 per cent.

On the twenty-seventh it was practically the same and on October 2nd leucocytes, 14,500; red blood-cells, 4,000,000; hæmoglobin, 65 per cent. On the third day he vomited a small amount of brown fluid and had a convulsion. The nurse's notes say that his whole body was rigid and his eyes were rolled back so far that you could not see the pupils.

RUPTURED SPLEENS

The next day I saw the case in a convulsion which lasted twenty minutes. We had to resort to morphine and he was given ten minims of Magendie's solution. He had three convulsions that day, but they were not as severe as the first one. The following day he seemed to be in a semi-comatose condition, restless, and irritable. Could not be forced to take any nourishment. In the evening he vomited a large amount of dark brown fluid, and at night it was necessary to restrain him. He remained in this condition for three days, but in the end he made a complete recovery and left the hospital in four weeks. The last blood count, taken the day before he left, showed: Leucocytes, 12,000; red blood-cells, 4,200,000; hæmoglobin, 85 per cent.

As far as I know, this child, whom I saw for a long time after the operation, has remained well.

CASE II.—A. Z., aged seventeen years, printer by occupation. Family and previous history negative.

Present History.—One-half hour before admission patient was struck by motor-cycle which was going in opposite direction to his bicycle. The motor-cycle struck the patient in the left hypochondriac region, where he suffers the most intense pain. He is very pale, complains of thirst and air hunger and is covered with a cold, clammy perspiration. Temperature, 102°; pulse, 102; and respirations, 22.

Physical Examination.—Medium-sized, well-nourished young man, the body covered with a cold sweat, presenting a picture of shock, heart and lungs negative, pulse rapid, feeble and somewhat irregular. Abdomen: Extreme pain and tenderness in the left hypochondriac region. A diagnosis of possible ruptured spleen was made. Upon operation he was found to have a ruptured spleen and on account of his condition no blood counts were made for several days. The third day following operation the patient had a profuse hemorrhage from the wound, which almost proved fatal. After several infusions he gradually improved and thereafter made an uneventful recovery. The blood count three weeks post-operative: Leucocytes, 12,500; hæmoglobin, 72 per cent.; red blood-cells, 4,000,000.

CASE III.—L. S., aged six years, admitted November 23, 1919. History of having been run over by a wagon. Patient was seen by me the following day. She complained of pain and tenderness over the entire abdomen and appeared to be in deep shock. The abdomen was distended and she had vomited several times since admission. On account of her condition a tentative diagnosis of ruptured spleen or ruptured intestine was made. At operation the spleen was found to be torn into several fragments and the organ was removed. The day after her operation she was transfused, with her mother as the donor. For eighteen days following the operation the temperature ranged from 101 to 104°. On the eighth day pulse was 160; respirations, 42. An inspection of the wound revealed nothing and an examination of the chest was negative. From the tenth day her temperature began to subside until the twenty-fifth day when it reached normal, and on the fourteenth day her abdominal wound showed signs of breaking down. There

seemed to be a complete digestion of the skin and muscles, till she eventually developed a large ventral hernia. A culture from the wound showed a staphylococcus infection. In spite of this infection this child ran a normal temperature, and seemed to be doing well until the fifty-fourth day when her temperature rose to 104° , where it remained for three days. On the fifty-eighth day her temperature was 106.4° , pulse 136, when she became restless and appeared unconscious. The following day she had a convulsion lasting ten minutes. After this convulsion she became delirious and remained in this condition for three days. Frequent examinations by the medical men during this time revealed nothing; her spinal tap revealed nothing, and the urine was normal.

From the sixty-sixth day her condition steadily improved and she left the hospital in very good condition, except for the ventral hernia. I have been in close touch with this child ever since and she appears to be well in every respect. I expect to operate for the hernia in the near future and hope to be able to report about the accessory spleens.

CASE IV.—S. A., aged six years. Admitted August 26, 1913. Half hour before admission was run down by a wagon, one of the wheels passing over the abdomen. Child was in shock, complained of great pain, was thirsty and presented the picture of internal hemorrhage. Temperature, 98.8° ; pulse, 148; respirations, 22.

Physical Examination.—Male, white, normally developed child, conscious and rational. Answers questions readily. Is suffering severe pain in abdomen and lower thorax; legs are drawn up on the abdomen. Complains of thirst. Is anæmic and restless. Head: No apparent injury. Eyes: Pupils equal and react to light and accommodation. Chest: Symmetrical, expansion fair but great pain on deep inspiration. Abrasions across the lower ribs more marked on the left side. Pain on pressure on left side and posteriorly. Lungs: Negative. Heart: Sounds are of good quality. Pulse weak and fast. Abdomen: General rigidity and tenderness most marked in the epigastric region. The blood count: White blood-cells, 17,500; polynuclears, 65 per cent.

On account of the distention which was more pronounced in this case a diagnosis of ruptured intestine was made. When the abdomen was opened it was filled with free blood. The spleen was torn into three pieces and the organ was removed. The child was taken to the ward in a very weakened condition. He was infused three times, but made a good recovery. Two weeks after the operation his blood picture was: Leucocytes, 16,000; red blood-cells, 3,000,000; hæmoglobin, 65 per cent.

The day before leaving the hospital he showed the following: Leucocytes, 14,500; red blood-cells, 3,600,000; hæmoglobin, 70 per cent.

CASE V.—M. L., aged eight years. Admitted August 26, 1913. Previous history: Had measles and pneumonia.

Present History.—While playing in the park fell from a rock about six feet high, striking on his forehead, with his heels bent toward the back of his neck. Apparently the child fell and struck his head falling backwards, hyperextending the abdominal muscles. Was conscious and

RUPTURED SPLEENS

rational when seen by the ambulance surgeon, but was apparently suffering great abdominal pain, breathing shallow and labored.

Physical Examination.—Undernourished boy of about eight years, conscious and rational but evidently in great pain. Pupils widely dilated, reacting to light and accommodation. Mucous membranes pale. Heart normal in size and situation, pulse very rapid and of low tension. Abdomen: Markedly rigid and tender throughout, not tympanitic; knees flexed upon the abdomen.

Diagnosis.—Possible internal injuries. Blood count: Leucocytes, 40,000; polynuclears, 80 per cent.

At operation we found free blood in the abdomen and discovered the spleen ruptured. The organ was removed. After forty-eight hours of anxiety he made a good recovery. He developed an infection of the abdominal wall which eventually cleared up. The last blood examination was as follows: Leucocytes, 17,000; polynuclears, 45 per cent.; red blood-cells, 4,500,000; hæmoglobin, 70 per cent.

CASE VI.—A. Z., aged eight years. Fifteen minutes before admission boy was run over by a truck. On admission temperature was 98.8°; pulse, 120; respirations, 20.

Physical Examination.—Fairly well-developed, nourished boy. White, conscious and rational. Pupils equal and react to light and accommodation. Extremities normal. Abdomen: Rigid and tense, especially in the left upper quadrant. Deep pressure caused him to have a great deal of pain, especially over the region of the spleen. Blood count: Leucocytes, 16,500; polynuclears, 76 per cent.

At operation free blood was found in the abdomen and upon examining the spleen a small tear was found from which blood was oozing. Pressure appeared to stop it, and I decided the organ could be saved. With two catgut sutures through the splenic tissue I was able to stop all the bleeding. For ten days the child seemed to be making a good recovery, but on the morning of this day his temperature rose to 104°; pulse, 146; and respirations, 46. The abdomen became distended and rigid and within two hours from the beginning of this condition he died. There was some vomiting and the abdomen was supposed to be the cause of death, but we were unable to get permission to do another operation and were left in the dark as to the real cause, for we were denied the autopsy. The day before his death the blood count was: Leucocytes, 14,000; polynuclears, 70 per cent.

SPONTANEOUS RUPTURES

In the cases reported you will find a previous history of such diseases as typhoid, typhus and malaria. As there is always a marked enlargement of the spleen present with these diseases you can readily understand how it might be possible for this organ to rupture spontaneously. The question as to the cause is debatable, whether it is muscular action or the over-distention of the capsule.

Connors and Downes, in *The American Journal of Medical Sciences*, reported one case and added twelve others.

In reviewing the literature I have found twelve others. The earliest of these is a case quoted by Atkinson in *The British Medical Journal* in 1874. Two other cases were reported in *The British Medical Journal* in 1878, one by E. Markham Skeritt and the other by Sidney Stone. In reading the histories of the cases carefully it appears that the only cases of spontaneous rupture in apparently normal individuals are those reported by J. E. Cannaday in *The Southern Surgical and Gynecological Transactions*, 1915, vol. xxvii, p. 514, and W. W. Shorten in *The British Medical Journal*, 1919, vol. ii, p. 844.

In the case reported by Cannaday a marked tuberculosis of the kidney was found. In the case of Shorten's there was no history of any of the diseases which might indicate a possibility of the cause of the rupture. The spleen appeared to be normal, both macroscopically and microscopically.

The complete history of my own case is appended.

CASE.—J. S., aged thirty-eight years, a driver by occupation. Admitted June 9, 1914. Previous history: Three months before admission was at another hospital under treatment for bronchitis, where he was told there was a possibility of pulmonary tuberculosis. Habits: Heavy drinker with frequent sprees. Venereal diseases denied.

Present History.—Three weeks previous to admission complained of pain in the right hypochondriac region which was increased on deep inspiration. Was unable to lie on right side. He was very constipated, having a movement once in three or four days. After severe catharsis bowels would move freely for one day, when the constipation would return. He was nauseated during his attacks of constipation. On day of admission he had very severe pain, sharp in character, in the left hypochondrium. Temperature was 99.8°, pulse 130, and respiration 22. Blood count: Leucocytes, 19,000; polynuclears, 78 per cent.; red blood-cells, 3,100,000; hæmoglobin, 45 per cent.; lymphocytes, 20 per cent.

A series of X-rays showed he had an obstruction in the region of the splenic flexure. From the history of constipation and the X-ray findings a diagnosis of obstruction (probably malignant) was made. At operation the intestine in the region of the splenic flexure was found to be normal. When the gut at this point was pushed aside, a very large hæmatoma presented itself, which ruptured as soon as my hand touched it. Upon examination this proved to be the splenic capsule. The spleen itself was almost bisected longitudinally by a rupture. When the hæmatoma was cleared away there was no sign of any active hemorrhage. When the spleen was removed, it seemed to be of normal size and consistency. The specimen was lost between the operating room and the laboratory, therefore no examinations could be made to accurately determine its true condition, but to the touch and appearance it was normal. I regret that I have no laboratory report to corroborate this statement. The question arises, when did the rupture occur? His initial pain three weeks previous was on the right side. The first pain on the left side occurred the day before his admission to the hospital. After considering the findings, I believe the rupture occurred that day,

RUPTURED SPLEENS

and the bleeding was checked by the intracapsular pressure. After the first week, during which time he was infused with saline, he made a good recovery and left the hospital in four weeks in apparently good physical condition. When the patient had recovered sufficiently I tried to elicit from him the history of any kind of trauma, but without avail. He gave no history of typhoid or malaria. No plasmodia were found in his blood and he had not been out of New York City since he arrived in this country several years before. His blood picture a few days prior to discharge follows: Leucocytes, 17,000; polynuclears, 75 per cent.; lymphocytes, 20 per cent.; red blood-cells, 5,600,000; hæmoglobin, 85 per cent.

I saw this patient several times and he was doing very well, but he disappeared for some time and returned to the hospital just three months later with the following history: For the past three weeks patient has complained of attacks of indigestion with eructations of gas. At the time of these attacks there is a great deal of pain in the abdomen in the region of the umbilicus. For some time he has been unable to stand in the erect posture on account of a dragging sensation in the region of the mass in the abdomen. This pain is markedly increased at every attempt to change his position. He has a sensation of something swelling inside him, which increases the pain and when able to belch gas is considerably relieved. On admission temperature, 98.8°; pulse, 90; respirations, 22.

Physical Examination.—Heart and lungs normal. Abdomen: Tender mass in the left hypochondrium, extending from the eighth rib to two inches below the free border. This mass appears to be cystic. Urine, negative. Blood count: Leucocytes, 20,000; polynuclears, 78 per cent.; lymphocytes, 20 per cent.

At operation a large cystic mass was found which seemed to spring from the location of the spleen and was bulging between the stomach and the splenic flexure. It was movable and was free from any adhesions to the surrounding organs. The summit of the cyst was brought to the abdominal wall where it was sutured. Upon opening it, it contained several ounces of a brownish-red fluid. We were unable to reach to the bottom of it and it seemed to be without a pedicle. The cyst was packed with iodoform gauze, the wound closed and drained.

The patient had very little reaction, but on the fourth day the whole wound broke down with what appeared to be the same infection which we had in the other splenectomy cases. There was very little pus but a marked erythema surrounding the point of drainage, which was similar to a digestive process of the entire area. This condition persisted for fourteen days and then healed completely. He was out of bed on the fourteenth day and left the hospital in fairly good condition forty-two days after operation. At the time of operation I removed a specimen from the cyst wall for pathological examination which showed mass of fibrous tissue with the walls of the blood-vessels very much thickened. There is a round-cell infiltration throughout the areas of hemorrhage. Blood count one week post-operative: Leucocytes, 13,000; polynuclears, 72 per cent.; lymphocytes, 22 per cent.

One month later: Leucocytes, 13,000; polynuclears, 76 per cent.; lymphocytes, 24 per cent.

The day before discharge from hospital: Leucocytes, 15,500; polynuclears, 82 per cent.; lymphocytes, 16 per cent.

In this case I feel certain that we were dealing with a pancreatic cyst which was the result of the injury to the pancreas at the time of the operation for splenectomy performed three months previously.

I saw this man for some time after this operation and he was in fair condition. I learned from one of his relatives that he died of pulmonary tuberculosis during my absence from this country in 1918.

HISTORIES OF SPONTANEOUS RUPTURES FROM LITERATURE

1. DAVYS: *Brit. Med. Jour.*, 1904, i, p. 1077. A Hindoo soldier, while resting in his tent, was attacked by severe pains in the region of the spleen and died within half an hour. Notwithstanding the most careful investigation no traumatism of any kind could be demonstrated. At the autopsy an extensive rupture of the spleen was found on the concave surface pressing towards the hilus of the organ, which was softened and twice the normal size.

2. PELLEREAU: *Annales d'Hygiène Publique*, 1882, vol. lvii, p. 223. In his medico-legal examinations of fifty-four cases of sudden death in the island of Mauritius, the author found fourteen of these cases to be due to rupture of the spleen. In five of these fourteen cases there had been no preliminary traumatism, and he accordingly designates them as spontaneous ruptures. Briefly summarized the cases are as follows:

A. Man, aged fifty-six years, admitted to hospital on account of pain in left hypochondrium, of ten days' standing. Sudden death a few hours after admission. Autopsy showed an enlarged and softened spleen, weighing 1000 g. At the anterior border there was a rupture, 8 cm. in length and 2 cm. in depth.

B. The second, third, and fifth cases are undoubtedly ruptures of malarial origin. The remaining case was a man who went to the barber shop for a haircut, sat down and asked for a glass of water, and before it could be brought to him he was dead. The spleen was enlarged, almost fluid, and presented a rupture of 4 cm. near the hilus.

3. SCHTSCHERBAKOFF: *Wratch. Gaceta*, 1907, No. 50 (Russian). *Jahresbericht für Chirurgie*, 1907. The patient had recovered from a severe illness, possibly typhoid fever. After a trifling bodily exertion he suddenly felt a sharp pain in the abdomen, and died soon afterward of internal hemorrhage. The autopsy showed a total transverse rupture of the spleen, the tissue of the organ was softened and very friable.

4. IVAN JOHANSON: *Revue de Chirurgie*, 1912, vol. xlii, p. 58. The author's observation on a case of spontaneous rupture of the spleen concerned a man thirty-nine years old, who for some time had been in poor health, and was suddenly seized with very severe pains in the abdomen, requiring immediate operation. Perforation, peritonitis, possibly complicated by internal hemorrhage, was suspected. The findings at operation suggested cancer of the stomach, with perforation and pelvic hemorrhage. The operation was not completed, on account of the poor condition of the patient, and he died on the third day. At autopsy, cancer of the stomach and the peritoneum, rupture of the spleen with hemorrhage into the peritoneal cavity were shown. The spleen was surrounded on all sides by a large quantity of fluid and clotted blood, it was ragged and torn, especially towards the upper pole, and was at least four times the normal size. The rupture occurred without any appreciable cause. From the pathologico-anatomical viewpoint there is reason to believe that the ulcerative and gangrenous cancer of the stomach gave rise, by way of the circulation (there were no adhesions between the stomach and the spleen), to acute

RUPTURED SPLEENS

septic splenitis in an already hypertrophied spleen. In the absence of all other etiological factors, such as malaria, leukaemia, Banti's disease and syphilis, etc., this hypertrophy must be regarded as of idiopathic origin.

5. J. MILLER: *Brit. Med. Jour.*, 1916, ii, p. 490. The patient, a man aged forty-four years, had syphilis twenty years ago, and at the present time was in the hospital for treatment of a septic condition of the hand which finally required the removal of a finger. Suddenly while trying to get out of bed to dress, he felt an acute pain in the epigastrium, and his condition became progressively worse, so that some hours later the abdomen was opened to the right of the middle line. An irregular tear was found on the anterior surface of the spleen, the splenic vessels were ligated and the spleen removed. The wound healed by first intention and the patient left the hospital some weeks later. The spleen was not examined, it was not enlarged, but it was friable, the operator's fingers easily making holes in it when grasping.

6. E. MARKHAM SKERRIT: *Brit. Med. Jour.*, 1878. Patient was admitted with a diagnosis of aortic aneurism. Shortly after admission, was seized with great dyspnoea and symptoms of collapse, which ended in death in less than an hour. At autopsy the capsule of the spleen was found greatly distended, and there was a tear of about an inch in the organ. The spleen was eight inches long, five and one-half inches broad, and three and one-half inches thick, weighing twenty-six ounces.

In this article he gives a short account of a medico-legal point in a murder trial at Ceylon, in which a coolie was struck on the head, knocking him to the ground, suddenly arose and ran away. In running away the coolie climbed over two walls and fell from one or the two of them; he then became quickly collapsed and died. At autopsy the spleen was very much enlarged and was found to be ruptured. The man striking the blow was convicted of murder.

7. R. SIDNEY STONE: *Brit. Med. Jour.*, 1878. An Indian woman carrying a large vessel of water on her head made a sudden movement to save the vessel from slipping, fell down and was carried fainting to her hut and died soon afterwards. No suspicion of violence. Forty-eight hours after death, on inspection, a large quantity of blood was found in the abdomen, which had escaped from three superficial tears in the spleen radiating from the hilus. The spleen was extremely large and soft and had a very delicate capsule. The stomach contained a part of a meal of rice.

8. R. SIDNEY STONE: *Brit. Med. Jour.*, 1878. An Indian woman visited her husband who was in a hospital suffering from ague and hypertrophy of the spleen. The latter became angry and attempted to strike her, and in trying to get out of his reach she fell to the floor, dead. Two hours after death an autopsy was performed, which showed fluid and clotted blood in the abdomen and a large tear in the spleen, which was already diseased.

9. W. W. SHORTHORN: *Brit. Med. Jour.*, 1919, vol. ii, p. 844. The patient, a man aged forty-three years, was suddenly attacked by a severe abdominal pain. This man had never been in a malarial country. A diagnosis of ruptured abdominal viscus was made. At operation a large rupture in the spleen was felt which divided the organ into two equal portions. Microscopical examination showed the spleen to be normal. No glandular enlargement followed. No blood counts were made.

10. LAMPE: *Dtsch. Zeitschrift für Chirurgie*, 1897, vol. xlv, p. 407. The patient, a man aged thirty years, had suffered for some time previously from a panaris. On lifting up a heavy object he felt a pain in the region of the spleen, and this was followed by sign of left-sided pleurisy. On operation the spleen was found to be ruptured and the softened organ lying bathed in pus. Splenectomy with recovery. The spleen was ruptured into several fragments.

11. J. E. CANNADAY: *Southern Surgical and Gyn. Transactions*, 1915, vol.

JOHN F. CONNORS

xxvii, p. 514. The patient, a man, aged twenty-four years, who had been under treatment for rheumatism, while riding in a railroad train was seized with severe abdominal pain. At operation a ruptured spleen was found, and the case also revealed a marked tuberculosis of the kidney.

CONCLUSIONS

1. It appears that the loss of the spleen has made no difference in the physical welfare of these patients.
2. The blood picture in these cases at the last blood examination revealed but a slight deviation from the normal.
3. The presence of the accessory spleens must be considered an important factor.
4. Direct blood transfusion is a great help in the successful outcome of these operations.

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SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN, WITH ABSTRACT OF CASES REPORTED BETWEEN 1842 AND 1921

BY WILLIAM E. LEIGHTON, M.D.

OF ST. LOUIS, MO.

PROFESSOR OF SURGERY, ST. LOUIS UNIVERSITY; VISITING SURGEON, ST. LOUIS CITY HOSPITAL AND BARNARD FREE
SKIN AND CANCER HOSPITAL

MY INTEREST in the subject of spontaneous rupture of the malarial spleen was aroused by the following case which came under my observation at the St. Louis City Hospital:

G. B., waiter, white, male, aged thirty-five years, was admitted to the medical service of Dr. George Richter, on the afternoon of October 22, 1912.

Present Illness.—Started two weeks ago with chills, fever and sweats. He had some vomiting. Three days ago he had another chill accompanied by nausea, vomiting and diarrhoea. Has been in bed past week. He had intense headache and severe pain in the epigastrium. There was no history of trauma. On admission to the hospital he had a distinct chill and vomited. The stomach contents were slightly bloody and bile tinged. He has lost about ten pounds in weight during the last three weeks.

Habits.—Smokes twenty or thirty cigars daily and drinks three or four glasses of beer daily. He sleeps well and has a good appetite. He admits having gonorrhoea nine years ago and a chancre on the penis lasting six weeks.

Past History.—Had scarlet fever when a child and pleurisy three years ago, but never had malaria.

Physical Examination.—Shows a man poorly nourished, pale and slightly dyspnoeic. He appears as in shock. The pupils are equal and react slowly to light and accommodation.

There is no nystagmus. The teeth are in poor condition. Tongue dry and coated. The cervical lymph-nodes are palpable. The chest expansion is good, but the breathing is costal in type. The heart dulness is within the normal limits. The apex beat is in the fifth interspace in the mammary line. Heart action is weak; no murmurs are present. The radial pulse is equal on the two sides, but rather fast and weak. The abdomen is rigid; tenderness can be elicited chiefly in the epigastric and splenic region. The spleen is enlarged and tender to the touch. A blood smear shows the presence of the malarial plasmodium of the tertian variety.

At 7.45 P.M. the temperature was 102° F., pulse 132, and respiration 32. He passed a very comfortable night until after midnight, when he complained of severe pains throughout the abdomen extending up to the heart. The night interne was called and administered an opiate. The next morning the patient was no better and Doctor Richter on his

morning visit made a diagnosis of perisplenitis with probable rupture of the spleen.

I was called in consultation and found the man suffering from severe abdominal pain confined chiefly to the epigastrium and right hypochondrium. The abdomen was slightly distended and the muscles rigid. There was a definite dullness in both flanks and exquisite tenderness over the entire abdomen. Nausea and vomiting were present. The whole picture was one of general peritonitis, and suggesting somewhat a perforating gastric ulcer. An exploratory operation was advised to which the patient consented.

Operation (October 23, 1912).—Under ether anaesthesia an incision was made through the left rectus muscle above the level of the umbilicus. When the peritoneum was opened there was a gush of dark fluid blood. On exposing the spleen two parallel rents were found on the external surface of the spleen from which blood was oozing. A gauze tampon was hastily placed between the spleen and the parietes, which was found to effectively check the hemorrhage.

The peritoneal cavity was sponged dry, and, as the hemorrhage appeared to be under control, it was decided that a splenectomy was unnecessary, and the gauze tampon was left in place, the ends protruding through the abdominal wound. The wound was closed in layers except for drainage. The patient made a good recovery from the anaesthetic, but on the next day developed a slight bronchitis accompanied by a copious purulent expectoration. During the night of October 27th the patient burst the wound open and some omentum protruded. This was replaced and the wound edges strapped with adhesive. On the next morning the patient was anaesthetized, the gauze tampon was removed, and the wound closed in layers with a small cigarette drain in the lower angle. From this time on the patient made good progress except for a small sinus which persisted for some time. The malaria disappeared under the use of quinine and the patient was discharged on January 22, 1913.

PELLEREAU (*Annales d'Hygiène Publique*, 1882, vol. lv., s. 223) reports five cases of spontaneous rupture of the spleen.

1. A man of fifty-six years was admitted to the hospital for a pain in the left hypochondrium which he had suffered for three days. Some hours after his admission he died suddenly. Autopsy showed a rupture of the anterior border of the spleen.

2. A man suffering for some days with a malarial attack died suddenly in his bed. Autopsy showed a rupture on the concave surface of the spleen.

3. A man of forty-four years who suffered from fever was seized suddenly with an intense pain in the left side. Two hours after his arrival at the hospital he died. Autopsy showed a rupture of the posterior surface of the spleen.

4. A professor while at the Barber's was seized with a pain, which becoming worse, he asked for a glass of water. Before it could be brought to him he was dead. Autopsy showed a rupture of the spleen at the hilus.

5. A fakir of forty-five years was treated in the hospital some days for malaria. One day while seated on the edge of his bed he fainted. Six hours later he died with symptoms of anaemia. Autopsy showed a deep rupture on the concave surface of the spleen.

SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN

6-20. MESSERER (*Thèse de Paris*, 1886) collected fifteen cases of spontaneous rupture of the spleen.

- Obs.
- III. Senac. Femme, rate hypertr.
 - IV. Brochet de la Bouttiere. Femme, rate hypertr.
 - V. Lieutaud. Homme, twenty-three ans, fièvre quarte.
 - VII. Bailly. Homme, twenty-six ans, f. int. pernic.
 - IX. Id. Homme, nineteen ans, f. quot. pernic.
 - X. Duret. Fille, thirty ans, f. intermitt.
 - XI. Krause. Homme, thirty-two ans, f. pernic. delir.
 - XV. Maillot. Homme, f. quotid.
 - XXI. *Arch. med. Soldat paludeen.*
 - XXV. E. Collin. Homme, forty ans, f. remitt. pern.
 - XXVI. E. Collin. Homme, twenty-six ans, f. remitt. gastr.
 - XXVII. E. Collin. Homme, twenty-eight ans, cachex. palud.
 - XXVIII. E. Collin. Homme, fifty ans, f. rem. icterode.
 - XXX. E. Collin. Homme, twenty-five ans, f. pern. delir.
 - XXXI. E. Collin. Homme, twenty-two ans, cachex. palud.

21. BORRALLIER (*Arch. Gén. de Méd.*, Paris, 1888, vol. ii, 299) reports a case of spontaneous rupture of the spleen following severe attacks of ague.

22. CIMBALLI, quoted by Litten ("*Northnagel Encyclopædia*"), p. 497, observed a rupture of the spleen in a man aged sixty-five years, who had an enlargement of the gland, the result of malaria. One morning as the man was getting out of bed he suddenly felt a severe pain in the left side and soon turned pale and cyanotic and died. A tear 3 to 4 cm. in length was found in the upper end of an enormously enlarged spleen.

23. BOWIE (*The Lancet*, 1892, vol. ii, s. 659) reports a case of a soldier of Blantyre, East Central Africa. Two weeks after his arrival he had an ague with vomiting. Had had several attacks of fever in the six weeks previous to his arrival. He felt well on the next day, but at 6 P.M. developed shivering and vomiting, and an hour later he complained of severe pain in his heart. Twelve hours later the resident physician was called and found him pale, anxious, extremely thirsty and suffering from pain in the hypochondriac region. The abdomen was not distended, but muscles were tense above the left hypochondrium. The patient gradually grew worse and died fourteen hours after the first sign of pain. Autopsy showed a rent in the spleen on the anterior external surface, four inches in length.

24. PALMER (*The Lancet*, 1892, vol. ii, s. 1437) cites a case of a man, aged twenty-six years, who never had a previous malaria. On September 22d, he had a shivering and vomiting and was treated by a ship captain with quinine. Seven days after the onset he applied at a hospital in Liverpool. Five hours later while in bed, he suddenly became very blanched and complained of great pain in the abdomen. He was unable to move. The left half of the abdomen as far as the midline was dull and extremely sensitive. He died within half an hour. Autopsy showed a rent three inches long over the lower part of the anterior margin of the spleen.

25 and 26. BOINET (*Deutsche med. Wochenschrift*, 1901, s. 294, v.) had five cases of rupture due to malaria. In two of these cases rupture was spontaneous (one of these occurring during the crisis of the fever).

27. BERGER (*Arch. für klin. Chirurgie*, 1902, Vol. lxxviii, p. 768) reports a case similar to the following.

28. DAVYS (*Brit. Med. Jour.*, 1904, vol. i, s. 1977) describes a case of a Hindu soldier who, while in his tent in bed, had a severe pain in the region of his spleen and died within half an hour. Not the slightest evidence of a trauma could be ascertained. Autopsy showed a large rupture on the concave surface of the spleen.

29. DALINGRU ("*Ref. Jahresbericht für Chirurgie*," 1901, s. 890) reports a

case cured by splenectomy. A woman, aged forty-four years, had attacks of malaria for a year. Three hours after admission to the hospital she had syncope and fever and was obliged to lie down. The spleen was greatly enlarged. An operation was performed and a cystic tumor found which, on examination, proved to be the splenic capsule filled with a large hæmatoma. There was no free blood in the abdominal cavity. A splenectomy was performed and the patient recovered.

30. TAYLOR ("Medical Jurisprudence," Fifth Amer. Edit., p. 281) refers to a case of a spontaneous rupture of the spleen which was enlarged and in a diseased condition, which was reported in the *Medical Gazette*, June, 1842.

31-61. CRAWFORD (*Ind. Med. Gaz.*, Calcutta, 1906, xli, p. 89) refers to Chever's "Manual of Medical Jurisprudence," in which he quotes thirty-one cases of spontaneous rupture of the spleen, of which twenty-six are quoted from a paper by Moller, of Königsberg, in the *Brit. and Foreign Medico-Chirurgical Review* for October, 1856, p. 543. These cases are not detailed by Chever, the references only are given. (1) One of the other cases came under his own notice, occurring in the Calcutta Medical College Hospital in a Danish seaman, who had been admitted for malarial fever with slight enlargement of the spleen. This case Chevers calls a perfectly well-marked and unmistakable case of spontaneous rupture of the spleen. (2) Another case he quotes is represented by Browne, of Hydresba, in the *Transactions of the Medical and Physical Society of Bombay*, 1855, p. 405. (3) A third is recorded by Porter, of Akola, in the *Madras Quarterly Journal of Medical Sciences* for October, 1866, p. 403. The remaining two cases are reported by Doctor French, (4) of Nowgong, in the *Ind. Annals of Med. Science*, No. xv, 1862, p. 273, and by (5) Doctor Wise, of Dakka, in the same journal in 1865, p. 329.

62-64. GIBBONS ("Medical Jurisprudence for India," p. 158) quotes three cases which came under his own observation in which rupture of the spleen appeared. After careful inquiry they were proved to have been absolutely spontaneous, no sudden muscular action having taken place at the time of the occurrence of the lesion.

65. CRAWFORD, in 13,000 post-mortem records, found only one case. A prisoner, aged seventy-five years, admitted to hospital for biliary colic, suddenly awoke with a pain in the belly and began tossing violently in bed, and became insensible and died immediately. Autopsy showed spleen eleven inches long, by three inches broad, with a rent of the superior and inner part, four inches long.

66-68. NOLAND and WATSON (*ANNALS OF SURGERY*, 1913, vol. lvii, p. 72) report three cases from the Panama Canal Zone.

1. Barbadian negro, male, aged twenty-two years, on Isthmus for two years. Had four light attacks of fever during this time. Admitted to hospital February 2, 1910. In the hospital nearly a week with malaria (æstivo-autumnal), proved by blood examination. No history of recent injury. On February 9, 1910, complained of pain in left side of body and developed marked abdominal rigidity. Leucocyte count 20,000. Operation refused until February 12th, when an abdominal section was made, revealing 500 c.c. of blood in the peritoneal cavity and a rent in convex surface of spleen, which was enlarged to twice its normal size and was wrapped around with omentum (nature's attempt to control hemorrhage). The wound was tamponed and ends left protruding through abdominal wound. Discharged April 12, 1910.

2. Spaniard, male, aged thirty-one years, on Isthmus five and a half years. Admitted to hospital August 6, 1911. Has had several attacks of fever. No history of recent injury. Sick four or five days. Blood examination positive for malaria (æstivo-autumnal). August 7th complained of pain centred about umbilicus. Next morning there was marked abdominal rigidity, tenderness, nausea and vomiting, abdominal distention and dulness in flanks. Leucocyte count 17,400. Operation

SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN

August 3d, revealed 1500 c.c. of fluid blood without clots and a shallow rupture on convex surface of the spleen, which was enlarged one and one-half times. No active bleeding was going on at time of operation, and the abdominal wound was closed without drainage. Patient discharged August 27, 1911. Smear of the blood in the peritoneal cavity showed a very æstivo-autumnal infection.

3. Jamaica negro, male, aged twenty-five years, on Isthmus four months. Has had four attacks of fever. He was admitted to the hospital December 16, 1911. Upon taking his midday rest he felt a sudden severe pain in the abdomen near the umbilicus radiating to the left costal margin. He complained of nausea and felt intensely weak. Abdominal rigidity and tenderness were marked, and dulness could be made out in each flank. Leucocyte count 24,000. Operation on December 16th revealed about 1000 c.c. of bright red blood in the peritoneal cavity and a rent on the convex surface of the spleen. Tampon was employed to control the hemorrhage. For twenty-four hours the patient's condition was good, then a total suppression of urine followed and the patient died. Autopsy showed a spleen weighing 140 grammes. Smear from the splenic pulp showed æstivo-autumnal plasmodium, while before death the peripheral blood did not show malaria.

69. DAVIDSON (*Texas State Journal of Medicine*, September, 1913), reports a case of a soldier who was in the Philippines in 1911. He had several attacks of malaria while there and since his arrival in the United States. While in the hospital with an attack of malaria (æstivo-autumnal) he had a rupture of the spleen for which a splenectomy was done on January 13, 1913. Two weeks after operation he developed the chain of symptoms which sometimes follow splenectomy. Irregular temperature, cramps in the abdomen, and pains in the leg and arms. He lost twenty-five pounds in weight, was weak and anæmic, his appetite was poor, but he was very thirsty. Red blood cells, 3,800,000; white cells, 18,000. These symptoms lasted two weeks but gradually subsided and on February 23d he reported for duty. On March 25th the red cells were 4,800,000 and the white 9000.

70. LEIGHTON and MOELLER (*Jour. Amer. Med. Assoc.*, 1916, vol. xli, p. 737). C. W. Four attacks of chill and fever previous to 1914. In August, 1915, had chills, fever, headache, malaria and pain in the abdomen, for which he was treated in the casualty clearing station six days. He was then sent to base hospital and while en route he was taken with severe pain in abdomen. Temperature on arrival was 97°. During the next two days he had several short attacks of pain simulating gall-stone colic. The pain, however, extended to the left hypochondriac region. During the night of August 25th he had a severe attack of pain in the epigastrium. Temperature, 97.4°; pulse, 120. Leucocytes, 10,500. No plasmodium found. On the following morning an exploratory laparotomy was made. The abdomen contained a large amount of old clotted blood and dark fluid blood. Spleen enlarged and quite soft, with the omentum firmly adherent to the external surface of the spleen. A search through the abdomen failed to find any bleeding point. The appendix, which was the seat of an old inflammatory process, was removed. Drainage was established. During the convalescence the patient began to have chill and fever. An examination of the blood showed the plasmodium. With the administration of quinine the patient made an uneventful recovery, except for a small sinus in the site of the drainage wound.

71. TURNER (*Lancet*, vol. i, p. 799, May 26, 1917). Case I. Sailor, aged thirty-five years, sick ten days, treated with quinine. June 17, 1916, on admission to British General Hospital at Basrah, temperature, 101.4°; pulse, 88. Abdomen flat, neither rigid nor tender. Plasmodium found on next day. Temperature 102.4°. Bowels had been well moved. In evening looked worse. Vomited several times. Had difficulty in breathing on 19th. He became restless and delirious and developed

convulsions, most marked in arms and lower jaw. Cyanosis, pulse quick and feeble. Death occurred at 10 A.M.

Post-mortem.—Moderate amount of clotted blood in peritoneal cavity. Spleen was twice normal size and on outer surface near upper pole were two small lacerations.

72. RANKIN (*Brit. Med. Jour.*, vol. ii, p. 211, August 18, 1917). Private, aged twenty-six years, in service seven and one-half years, admitted to British General Hospital March 29, 1917, for acute abdominal pain. Was cold, collapsed, cyanosed and without perceptible radial pulse. Abdomen not rigid. Dulness in left flank. Marked cyanosis of finger nails. Operation. Free blood found in peritoneal cavity. A big spleen was found, the capsule was torn. Spleen was removed. Wound healed well and he made a good recovery. Blood examination showed plasmodium, no crescents found.

Previous History.—He had served in India three years. There he had an odd day or two with attack of malaria. In 1916, while at Salonica, he was in hospital for five days with malaria. Took quinine for three weeks. He was operated on for appendicitis and invalided home. From beginning of 1917 he had discomfort in his stomach and whenever he worked had vomited on several occasions. He arrived in France the day before his admission to the hospital. He had been uncomfortable for five days. He marched to his depot, took ill with abdominal pains during night and when seen by his medical officer was immediately sent to the hospital.

73. LEIGHTON. Abstract of case reported. G. B., white male, aged thirty-five years. Never had malaria previous to present illness. Present illness began two weeks ago with chill, fever and sweats. Three days ago chills, nausea, vomiting and diarrhoea, intense headache and pain in the epigastrium. He had suffered no injury. Had been in bed for practically two weeks. No history of trauma. Spleen is enlarged and tender to the touch. Blood examination showed the presence of the malaria plasmodium of the tertian variety. Passed a comfortable night in the hospital until towards morning, when he complained of severe pain. The interne administered an opiate. The next morning the patient showed collapse and evidence of peritoneal irritation. An exploratory operation was performed. The abdomen was full of blood, which was found to issue from two parallel rents on the external surface of the spleen. A gauze tampon was inserted, which effectively controlled the hemorrhage. The ends of the strands were left protruding from the abdominal wound. The patient was discharged on January 22, 1913.

Frequency.—Deadrick, in his practical studies in 1911, says: "Rupture of the spleen is an infrequent complication of malarial cachexia. It is rarely associated with acute malaria, though a case has been recorded by Palmer in which rupture occurred within seven days of the onset of the fever. The rupture may be spontaneous or the result of blows or falls."

According to Deadrick, the lacerations occur with about equal frequency on the concave and convex side of the spleen. Tears of the inner aspect may occur without marks of violence of either the skin or convex surface of the spleen. A light sharp blow tends to injure the convex surface, a fall or a crushing blow the concave side.

In 123 cases of traumatic rupture of the spleen, collected by Berger, ninety-three showed malaria.

Cantlie calls attention to the frequency of rupture of the visceral surface in malarial spleens, the result of trauma, while in Nolan and Watson's and

SPONTANEOUS RUPTURE OF THE MALARIAL SPLEEN

my own cases the tear in each instance was on the external or diaphragmatic surface.

Symptoms.—The symptoms of a spontaneous rupture of the malarial spleen consist of violent pain in the splenic region referred to the left shoulder and region of the heart together with evidences of shock and hemorrhage. In 1898 Balance described a sign, since known as the Balance sign, which consists of the following phenomena: Dulness in both flanks when the patient is in the prone position. On turning the patient on the left side the right flank is resonant, but on turning him on his right side the flank remains dull, due to the blood clots adhering to the rent in the spleen.

Treatment.—The treatment is essentially surgical, although Skerritt reports a case which apparently recovered without operation. Mackenzie reports that one of his cases died eighteen hours after the rupture, although 68.9 per cent. died within a half hour of the occurrence. Death takes place from hemorrhage and the shock attendant on it, and the only chance of saving the patient depends on the possibility of arresting the bleeding.

"Finkelstein (*Brit. Jour. of Surg.*, 1914, p. 68) reports eleven cases of spontaneous rupture of the spleen from various causes. Seven of these were treated by operation, but only three recovered. He concludes that if we take into consideration the fact that this spontaneous rupture was due to a virulent infection, and that the diagnosis was not exact, then we cannot regard the mortality rate as very high, for such patients, if not operated on, succumb almost without exception.

"In most cases the spleen must be removed. Exceptionally when the rupture is slight and superficial, suture or tamponage can be employed. The recent experiments of Lebedev confirm the treatment of wounds and ruptures of the spleen by suture. Kirchner showed that bleeding from a ruptured spleen may be controlled by enveloping the organ with omentum. Thus we may hope in the future not only to lessen the mortality, but also in many cases to save the organ by employing the above-mentioned conservative methods."

The operative mortality of all cases of spontaneous rupture of the malarial spleen recorded to date is as follows:

Operation		" Splenec- tomy	Tampon- ade	Recovered	Died
Leighton	2*		1	2	
Davidson	1	1		1	
Nolan and Watson ...	3*		2	2	1*
Dalingru	1	1		1	
Rankin	1	1		1	
	8	3	3	7	1

This gives a mortality of 12.44 per cent.

* Hemorrhage had ceased in one case and nothing was done. The patient of Nolan and Watson died from anuria three days later.

SURGERY OF CYSTS OF THE SPLEEN

By ROYALE H. FOWLER, M.D.
OF BROOKLYN, N. Y.

THE literature of the surgical pathology of cysts of the spleen includes contributions by Aschoff, Beneke, Boettcher, Coenen, Fink, Otto, Renggli, Ramdhor, Schmidt, the writer and others. In 1904 the subject became one of greater surgical interest. Contributions appeared in Germany at that time by Heinrichius, Monnier, and Lasperes. The subject had been ignored in American and English literature until 1905, when Bryan's monograph appeared in this country. Powers, of Denver, writing in 1906, ignored this article. He also overlooked a few isolated cases. Powers analyzed thirty-two cases up to 1906. Bircher wrote an exhaustive article in German in 1908.

The writer has collected eighty-six cases of non-parasitic cysts of the spleen up to 1912. Of these, twenty-eight were discovered at autopsy. In eleven the diagnosis was made by trochar. Fourteen were treated by incision and drainage, six by excision of the cyst, and twenty-seven by splenectomy.

Since 1913, when the writer's last article appeared, a few isolated reports of non-parasitic cysts of the spleen have been published. The present contribution aims to continue the study first undertaken by the writer in 1910 and to add a case of dermoid cyst and studies of parasitic cysts. In his previous review all available cases collected from all sources of non-parasitic cysts of the spleen were critically analyzed.

The general classification previously adopted, (1) dermoid, (2) non-parasitic, (3) parasitic, well covers these forms which are found in the spleen.

Dermoid Cysts.—There are but two authentic cases on record. One case, reported by Andral in 1829 which contained hair and sebaceous material, has been included in my previous contribution. A second additional undoubted case is reported by Kummaris from the Institute of Surgical Anatomy and Operative Surgery, University of Athens, as follows:

The patient was a woman of forty years. When two years of age she fell from a balcony apparently without bad effects. She has been married fourteen years and has borne two children. For five years she had noticed an increase in size of the abdomen. At the same time varices and pain in the left leg developed after a slight disturbance of menstruation and periodic gastro-intestinal derangement. Upon examination there was a tense cystic tumor in the lower abdomen which occupied the pelvis and extended to the navel. The pre-operative diagnosis was ovarian cyst. At operation no free fluid was found in the peritoneal cavity. The omentum covered a thick-walled cystic tumor which was adherent for the most part and situated in the pelvis. There were firm adhesions to the intestinal coils. The tumor, larger than a man's head, was delivered with difficulty. The spleen was not in its normal situation. The uterus was three times its normal size and myomatous, adnexæ normal. The growth was found to spring from a dislocated spleen. It was impossible to remove it on account of the firm adhesions. The cyst was punctured and emptied of a litre of peculiar fluid which consisted of a brick-red thin sub-

SURGERY OF CYSTS OF THE SPLEEN

stratum and a number of regular, round, white, shot-like little balls. A portion of the cyst wall was removed for diagnosis and the growth marsupialized. A large amount of hair was removed from the cystic cavity. The post-operative course was normal. Patient discharged in thirty days with a fistula. Histologic appearance showed that the cyst wall was uniform, and consisted of connective tissue. Blood-vessels were engorged, tissue showed some hyaline degeneration. There was considerable hemorrhage. There were collections of hæmosiderin crystals. The interior of the cyst was smooth and without epithelial lining. The fluid contained blood-corpuscles. The fat balls when crushed consisted of round fat-droplets, which stained easily with Sudan III. There were no cholesterin crystals. Examination showed that the fat balls remained unchanged when placed in water heated to 100°, but at 120° they broke up.

Non-parasitic Cysts.—The classification of these cysts offered by the writer in 1913 has been slightly modified. The following is rational and is based on the mode of origin:

I. *True Cysts.*—1. Infoliation Cysts. (Inclusions of peritoneum—inflammatory or traumatic, small and multiple—may be superficial or deep.) 2. Dilatation Cyst. Polycystic disease of the spleen (Coenen, Fowler—ectasis of splenic sinuses—multiple). 3. Neoplastic Types (lymphangioma, hæmangioma). It may not be possible to distinguish Group II—polycystic disease which may be borderline in its tendencies between inflammatory and neoplastic hyperplasia—from Group III—actual new growths. The differential criterion is still obscure.

II. *Pseudocysts, Secondary.*—1. Traumatic Cysts. These may arise from a hæmatoma and are usually large and unilocular (hemorrhagic and serous cysts, so called from their contents). 2. Degeneration cysts arising from secondary changes in infarcted areas from arterial degeneration, or occlusion of blood-vessels by emboli with consequent necrosis of the spleen pulp. These are also usually solitary and large.

A review of the literature from 1912 to 1921 reveals a few additional reports of non-parasitic cysts of the spleen.

A. CERNE reported a serous cyst of the spleen, in 1914, before the Medical Society of Rouen, in a male patient, aged twenty-seven years, who had had a bronchial hemorrhage while serving in the artillery in 1909. He had a second hemorrhage and bronchitis in 1911. Immediately after his marriage, in 1911, he noticed an abnormal swelling in the left side of the chest. The condition was diagnosed a liquid tumor, probably a hydatid. It grew very rapidly in the last months of 1913. There had never been any urticaria. The reaction of Weinberg for hydatid disease was negative. Radioscopy showed the stomach to be elongated and pushed back almost in the right iliac fossa by the tumor. Operation was performed. Puncture of the cyst showed at once it was not a hydatid. About three and one-half litres of liquid was ejected. Incision of the sac did not reveal any membrane. The sac was not adherent, and inasmuch as the cyst was central, splenectomy appeared to be definitely indicated. The patient left a month later; improved but not cured. The tumor presented the appearance of a large hydronephrosis. The splenic tissue was thickened at the two ends and on top; it surrounded the cyst on the internal aspect, where the wall was markedly fibrous.

BACIGALUPO and GROSSO, in 1919, reported a post-mortem case of multiple serous cysts of the spleen in an infant of one year, who died of bronchopneumonia. During life there were no symptoms suggestive of splenic disorder. The spleen was normal in color and size. On the outside surface, near the posterior edge, was a small elevation, with a pro-

tuberant white point. In this location was also noted a slight resistance. The postero-internal surface revealed in the centre a globular elevation similar to a tumor. The antero-internal surface showed nothing worthy of mention. There was also an accessory spleen of the weight of a grain of rice. The cysts, when cut, showed a cavity the size of a large filbert, and were filled with a serous limpid liquid.

ADRIAN LAMBERT also dealt with the subject of non-parasitic cysts of the spleen in 1919. A woman, aged thirty-four years, was admitted to the hospital July, 1918, complaining of loss of weight, weakness and pain in the epigastrium. Her father had died of cancer of the stomach; her mother, from cancer of the mammary gland. A sister had died of tuberculosis of the intestines. The patient had a severe attack of malaria twenty-two years previously, and twelve years ago had been severely injured on the left side of the body in an automobile accident. In 1912 she had a left ovarian cyst and the vermiform appendix removed. For three years the patient had had a dull pain in the epigastrium while walking and extreme nausea. The nausea appeared to be relieved only by abstaining from all food. On physical examination no glandular enlargements were to be felt. Heart and lungs were normal. There was tenderness on deep pressure over the left side below the free border of the ribs. The spleen could not be felt. Gastric analysis showed a trace of occult blood with benzedin test. Free HCl 36. Total 50. Blood picture showed slight increase in leucocytes. Red blood-cells 3,800,000; hæmoglobin 78 per cent. No blood in stools. The X-ray revealed a "pseudo hour-glass stomach." Splenectomy was performed. Recovery was uneventful.

Pathological Report.—The spleen was increased greatly in thickness as well as size. Over several areas the peritoneal covering was missing. The spleen measured 9 x 8 x 6 cm. On the convex surface were two distinct prominences, elastic and fluctuant, which were the site of cystic cavities. The walls of two cavities (which communicated with each other) were smooth and shining and presented numerous ridges on the surface. In many places the septa separating the different loculi of the cystic cavity were reduced to thin transparent folds, having sharp, free edges projecting into the cavity of the cyst. The content of the cysts was a clear, amber-colored fluid, too thick to be drawn through a fine hypodermic needle. The cyst wall could easily be stripped from the surrounding splenic pulp as a distinct membrane, even directly beneath the capsule of the spleen.

This author does not believe that the fluid contents of the cyst is a true secretion, but rather that it is a product of osmosis or transudation. He believes that an exhaustive study of the chemical composition of the cystic fluid would be valuable. Such a study was not made. Lambert is of the belief that the cyst formation in the above case was due, as in Bötcher's case, to amyloid degeneration and consequent occlusion of the blood-vessels resulting in an area of necrosis which ultimately became cystic. The presence of old thrombosed blood-vessels tended to confirm this.

HAMILTON and BOYER have more recently written on hemorrhagic cysts of the spleen and report two cases. Case II is worthy of note. The patient was a girl of twelve years. There was a history of abdominal injury four years before operation, and again five months prior to operation. A swelling of the abdomen antedated her last injury by two months. After that, however, it grew rapidly in size. At operation adhesions were present to omentum and diaphragm. Splenectomy. Recovery. There was a single large cavity which occupied all the spleen but the outer lower third of the organ. The wall was lined by an intricate network of anastomosing blood-vessels. There were scattered areas of pigment and foreign-body giant-cells. The arteries in the pulp were abnormally thickened. The remaining portion of the spleen was normal. The contained fluid resembled black coffee. Specific gravity, 1022, amount 620 c.c. Microscopically red blood-cells in rouleaux formation and a few leucocytes were found.

Etiology.—In my previous paper the influence of contributory factors of age, sex, pregnancy, antecedent disease of the spleen and trauma, etc., was evoked in the attempt to throw light upon the etiology.

SURGERY OF CYSTS OF THE SPLEEN

Including the four latest reports, age was stated in fifty-one cases:

Under one year, 2 cases; one to ten years, 2 cases; ten to twenty years, 9 cases; thirty to forty years, 17 cases; forty to fifty years, 14 cases; fifty to sixty years, 3 cases; sixty to seventy years, 4 cases.

In the majority the disease has affected persons in middle adult life. In but two were cysts found in infants under one year. This would speak against their congenital origin, but would not exclude the possibility of the autopsy cases; all but one occurred in individuals over thirty.

Females are predisposed to this condition. Of sixty-eight cases in which the sex was stated, forty occurred in this sex. The majority occurred between the ages of twenty and forty during the child-bearing age. Of the fourteen cases which were studied at autopsy, one occurred in a female. Monnier explains the predilection for the occurrence during the reproductive period of woman by the fact that the spleen becomes congested in pregnancy, during menstruation, and at the menopause, and subsequently relaxes. In six cases in this series there seemed to be some relation between pregnancy and cyst formation. The contents of the cysts which showed relation to pregnancy are stated in five cases. Of these, three were blood-cysts and two lymphatic. In Bircher's case "something" was discovered in the course of pregnancy alongside of the uterus, which subsequent operation showed to be a displaced cystic spleen. Routier's case showed rapid increase in growth following pregnancy and normal labor, which occurred one year previously. In Wells' case an already existing tumor was found to be stimulated to increased growth by pregnancy. Cönen operated in the course of pregnancy and excised a spleen the seat of polycystic disease. The splenic tumor was first observed following previous childbirth. In the case observed by the writer the abdominal tumor was noticed three months after childbirth. Downs reports the development of a cyst of the spleen, which he incised following confinement. The walls were necrotic. "Almost the entire spleen came away in sloughs." The most rational explanation of the development of cysts of the spleen following pregnancy is that embolism, which may occur in this state, leading to infarction and secondary hemorrhage, may eventuate in cyst formation. This explanation would seem to hold good in the cases of Bircher and Downs.

Congestion of the spleen may explain the increase in size of an already existing tumor. The influence of pregnancy upon the formation of lymphatic cysts is not so apparent in Cönen's case. Mechanical dilatation from pressure is a possible explanation.

Antecedent diseases of the spleen may exert an influence, especially malaria and syphilis. Hypertrophied spleens, moreover, are more likely to be recipients of injury, consequently hæmatomas could be readily formed. Perisplenic adhesions are prone to occur in hyperplastic spleens. There seems to be some relation between perisplenitis and the formation of cysts. Brunswig-le-Bihan states that in Arabs hemorrhagic cysts, due to ruptures restricted by adhesions, are not uncommon. Adhesions, it must be remembered, may be the result of cyst formation as well. Malaria was stated to have been present in

eleven cases. The spleen was found to be enlarged in those cases giving a malarial history. They were all unilocular blood-cysts except three. One specimen showed small, superficial multiple cysts with serous contents. A second had serosanguinous contents. It is conceivable that spontaneous rupture of a distended capsule from congestion of the pulp incident to typhoid fever, etc., might predispose to cyst formation. The relaxation and shrinking upon subsidence of hyperæmia leaves the capsule in a wrinkled state with countless furrows which might easily become sealed over by inflammation and result in infoliation cysts. The relation of peritoneal surface cysts to spontaneous rupture of the capsule of an overdistended spleen, the seat of perisplenitis, may be intimate. Subbotic observed small multiple surface cysts in malarial splenomegaly which possibly originated in this way. Syphilis was mentioned in two history records. In one the initial lesion occurred six years previously (Garcia); in the other case the history of the infection was lacking, but there was evidence of the disease in the blood-vessels and viscera (Harnett). Aside from the greater danger from exposure to trauma to which an enlarged syphilitic spleen might be subjected, resulting in an hæmatoma, its liability to perisplenic adhesions with the subsequent development of infoliation cysts, cysts may occur within the parenchyma of the spleen the result of specific endarteritis. Harnett considered that the spontaneous rupture of an intrasplenic blood-vessel was responsible for a case which he observed occurring in a man who gave post-mortem evidence of syphilis, although neither the spleen nor its vessels showed evidence of this disease. Bednar stated that cysts of the spleen are frequently associated with pemphigus, and describes a small cyst occurring in a child of one week born with the disease. In one case observed by Fereal a large abdominal tumor formed during an attack of mumps. Operation subsequently revealed it to be a cyst of the spleen. Aside from malaria and syphilis there does not seem to be any relation noted in reports which have been studied between diseases causing splenic enlargement and cysts of the spleen.

In the etiology of large cysts of the spleen the one most generally acknowledged factor is trauma. Injury was stated to have preceded the development of cysts of the spleen in nineteen cases. The interval between injury and development was stated in fifteen cases. In six cases the cyst developed within one year or less, in seven cases within ten years or less, in one case (Lambert) after a lapse of twelve years, and in one the cyst did not develop until forty years had elapsed. Such a long period of time would seem to exclude any relationship. Of those cases which showed a relationship to trauma in which the contents of the cyst were stated, thirteen were hemorrhagic, one was lymphatic and two serous. The injury has usually been a direct blow or a fall upon the abdomen. Long-continued pressure of the left lower chest against a machine was mentioned in one case and a penetrating wound of the abdomen involving the spleen was mentioned in another case. The history of trauma cannot be taken as proof of the origin of any particular kind of cyst, although hemorrhagic cysts seem to develop most frequently.

SURGERY OF CYSTS OF THE SPLEEN

The relationship of cysts arising from inclusions of peritoneal endothelium in consequence of gross injury (traumatic infoliation cysts) is a theory which should be mentioned.

Among these etiologic factors must be considered the influence of a twisted pedicle. This is suggested by its occurrence in two cases. In Bircher's case the twist was not held responsible. The pedicle was twisted upon itself about 360 degrees. The cyst did not represent a large central area of necrosis which would follow the arrest of blood at the main source of supply. Under such an influence it is likely that the entire spleen and not a part of it would be involved. A peripherally located cavity in the spleen otherwise intact could hardly result from torsion of the main vessels. In Küstner's case the gastro-splenic ligament showed undoubted evidence of strangulation. He believes that this was the cause of the cyst formation. The cyst occupied four-fifths of the spleen. The parenchyma was reduced to a small, narrow, wedge-shaped area. He is of the opinion that hemorrhage occurred from stasis and that destruction of splenic tissue resulted in the cavity. One can hardly reconcile such a cyst as this writer describes with such a degenerative process.

Pseudo Cysts: Pathogenesis.—Nothing has been added in recent years in explanation of the more intimate mode of origin. This can be explained in a variety of ways as is proved by histologic findings. Each variety originates in quite a distinctive manner. The genesis of cystic spleen seems to have no points of analogy to the genesis of cysts of the ovary and kidney. In the absence of tubular structure true retention cysts do not occur. An association has been demonstrated between non-parasitic cysts of the liver and congenital anomalies, especially cystic kidney. There would appear to be no such association in the case of the cysts under discussion. If we distinguish true cysts from pseudo cysts (resulting from hemorrhage and necrotic or infarcted areas of parenchyma), the problem is not so complex.

In thirty-four of the forty-four cases in this series which showed hemorrhagic contents, the history or the pathologic findings indicate a possible mode of origin. Nineteen probably resulted from trauma, five from disintegration (two from infarction and three from arterial degeneration). Eight were cysts into which secondary hemorrhage had occurred (four serous, four lymphatic). Two were to be regarded as neoplasms (angioma). In this class, then, rupture of blood-vessels, spontaneous or traumatic, figures most conspicuously. Spontaneous rupture of diseased blood-vessels and hemorrhagic infarction are more rarely the factors concerned. Secondary hemorrhage is of fairly frequent occurrence. It is difficult to determine the frequency with which disintegration cysts occur, inasmuch as evidence of ruptured intrasplenic aneurism, diseased blood-vessels, splenic infarction, and embolism would rarely be present after such a process had formed a cyst.

Pathology.—In twenty-five cases analysis showed contents to be serous. The large unilocular single cyst may be said to originate secondarily from the subcapsular hæmatoma or intraparenchymatous hemorrhage, the fluid contents of these becoming clear through the deposit of cellular elements upon

the walls. Nine cases of large, single, isolated unilocular cysts were studied, of which two were thought to develop from hemorrhagic cysts, one from a twisted pedicle and one was thought to be transformed from a multilocular lymphatic cyst through destruction of the interior network. In two cases large, single, unilocular cysts were associated with small multiple cysts. In three specimens cysts were small, single, and situated deep in the organ. Small, deep, multiple cysts, however, originate in a different manner. According to Boettcher, they may arise in consequence of amyloid changes which occur in the blood-vessels of the spleen causing degeneration of the area supplied by them. This investigator claims that these degenerated areas subsequently develop into serous cysts. He traced an arterial branch to the wall of such a cyst and to a point in the parenchyma which was involved where it suddenly stopped.

In forty-four cases in this series the contents were stated to be hemorrhagic. Nineteen were subcapsular hæmatomas. These are usually large, single, and unilocular. There is rarely any evidence of a recent or active hemorrhage. The wall of the subperitoneal hæmatoma is composed superficially of the capsule, and upon the remaining sides the cyst is surrounded by parenchyma. There is no distinct epithelial lining. The wall is composed of connective tissue if organization has taken place, and contents vary according to the age of the cyst. These cysts may contain as much as ten litres of blood, which may be coagulated or fluid, of black or brown color, depending upon the stage of alteration.

The contents usually become fluid, thin, clear, or remain thick. The interior may be irregular and show no definite encapsulating wall, or it may present the appearance of an aneurism. Disintegration cysts into which hemorrhage has occurred may present necrotic walls and show no evidence of embolism or infarction. Other cysts into which secondary hemorrhage has occurred and angæma need no description. Hæmatoidin and cholesterin crystals are usually present in old cysts. Intraparenchymatous cysts arising from arterial disease may present the characters of the above.

Of twenty-five cases of serous cysts nine were small superficial multiple cysts (four of these were multilocular). Lambert's case showed two large communicating cavities. Two cases of large isolated cysts were associated with small multiple cysts. Nine were large solitary cysts with a single cavity. Solitary unilocular cysts with serous contents may be enormous and have been described as as large as a football. They project as a globular mass from the surface and are smooth except for the occasional presence of adhesions. They are usually limited superficially by the splenic capsule beneath which they are situated and partly surrounded by parenchyma. The smaller unilocular cysts may be entirely surrounded by splenic tissue. This is true of those deep-lying serous cysts originating from intraparenchymatous hemorrhage and pulp degeneration. Those which have been transformed into the serous variety from the subcapsular hæmatoma may show a smooth interior of organized connective tissue from the deposits of cellular material and fibrin. The walls

SURGERY OF CYSTS OF THE SPLEEN

may appear smooth, laminated, rough or irregular. The interior never shows an epithelial lining, but occasionally a layer of fibroblasts or round cells. Boetcher describes multiple serous cysts within the parenchyma, from the size of poppy- to that of hemp-seed. He states that the pulp in his case was infiltrated and the capsule thickened. The vessels and connective tissue showed amyloid degeneration. The cysts were close together. The smaller ones contained, in addition to serum, fat and fibrin. The walls showed an endothelial lining separated by splenic tissue and a fibrinous septum. In places cavities merged into each other. The vessel walls were greatly thickened by amyloid changes and constricted.

TRUE CYSTS.—Pathogenesis.—**I. Infoliation Cysts.**—Beneke is of the opinion that small multiple surface cysts originate from the infoliation of peritoneal endothelium, in consequence of traumatic rupture of the splenic capsule. It was claimed by him and his pupil, Ramdhor, that the splenic tissue protrudes through these ruptures, which he terms "Hernias of Splenic Tissue," becomes snared off between neighboring areas of parenchyma and forms cystic cavities. He considers the cells lining the cysts and the endothelium of the peritoneum identical. Small superficial cysts with serous contents as described by M. B. Schmidt are frequently found on the anterior border of the spleen, seldom upon the posterior border or convex surface, and rarely upon the concave surface. These little cysts give the organ a beaded appearance. They do not usually extend into the parenchyma more than 1 cm. They are about 0.5 cm. in height and seldom more than 1 cm. in diameter. Schmidt states that he has observed many cases post mortem. Mueller found these cysts of the spleen in 11 per cent. of his series of autopsies. These small surface cysts occasionally show bloody contents. They are usually isolated and unilocular. Ramdhor describes in addition deep furrows in the spleen and at the anterior border dense groups of cysts the size of a small pea, tense and filled with clear fluid and occasionally with a mucous colloid-like substance. He also describes numerous excrescences scattered over the capsule resembling splenic pulp. These hernial projections were covered with a layer of epithelium. In rare instances an interlacing network has been present in the interior of small superficial multiple cysts. M. B. Schmidt also holds Beneke's view and states that these cysts commence as little red excrescences which extend over the surface and appear through the rents in the capsule. Schmidt states that almost all small superficial cysts originate from tissue hernias. He has found many such instances at autopsy in which there had been swelling of the spleen.

Wohlwill believes that trauma is not essential to the development of infoliation cysts, but that the rupture of the splenic capsule and hernia of the splenic tissue ensue from a rapid swelling of the organ. As the spleen continues to enlarge, spontaneous rupture takes place at various points, peritoneum becomes turned in and snared off after the manner of a dermoid.

Renggli describes cysts of the spleen lined with cubical epithelium and offers an explanation in regard to their development. He also attempts to

explain the occurrence of deep multiple cysts from snared-off peritoneal endothelium. He substitutes inflammation for trauma as a necessary precursor. Renggli believes that in consequence of the fusion of proliferated areas on the surface, due to inflammatory process, the endothelium becomes snared off and in situations where such areas have been pressed deep into splenic tissue is stimulated to energetic growth and cyst formation, the cyst coming to lie deep in the parenchyma. He considers that the single layer of cuboidal epithelium lining these cysts is the same as that which composes the peritoneum, except that the peritoneal endothelium of the surface has become flattened from the pressure of the neighboring organs. He places the origin of these cysts in the period of embryonic development, when the endothelium of the peritoneal cavity shows its original cuboidal character.

Otto is not of the opinion that deep cysts arise after the manner of Renggli, but considers that small superficial cysts possessing a flat layer of cells unsurrounded by splenic tissue may have this origin. Zeigler in his text-book of pathology mentions the Renggli theory, but states that such cysts are rare. Kühne has dealt with the subject and reports three cases. In investigating the cause he concludes that the theory of Renggli is quite reasonable and holds good in one of his cases.

Since the presentation of my previous paper in 1913 an Italian article by Pepere, published in 1912, has been made accessible, which deals with the origin of multiple cysts of the spleen.

Pepere contends that all the so-called serous cysts of the spleen originate from cellular nests, which remain under the splenic capsule from abnormal invaginations of the perisplenium during the development of the organ. Usually these cellular residues disappear but at times they remain, giving rise to subcapsular cysts. When through absence of any element capable of disturbing the primary genetic relations, the connections remain between the connective endothelial layers of the perisplenium and those of the cysts, the reconstruction of the process is easy. It is evident that with this abnormal invagination of the perisplenium there will not in every case remain one group only of endothelial cells which will later transform itself into a single cyst. We know that in many cases a great number of cells will remain caught under the perisplenium or in it, surrounded by more or less connective tissue. Such a disorder takes place preferably in the bottom of the sulci which separate the primitive lobes, and which gradually fill up as the organ develops. That is why serous cysts are frequently located in the superficial and mostly marginal portions of the spleen. He does not doubt the development of fetal subcapsular invaginations of the peritoneal endothelium, but these should be corroborated by the presence of fragments of cells found in the healthy spleen, without cysts; he has not, however, found any due perhaps to the comparatively advanced age of the subject. It is obvious that the endothelium, detached or buried between the fibrous layers of the capsule, must necessarily be absorbed, while it is seldom that it remains to be transformed from a single nest of cells into cysts. The results that take place in the spleen are

SURGERY OF CYSTS OF THE SPLEEN

something similar to what happens in the pelvis of the kidney, in the ureters, in the bladder, to the nests of von Brunn's cells, which according to some authors transform themselves from congenital productions into pyelitic, ureteral and bladder cysts, respectively.

Further analogies which lead Pepere to believe in the origin of the small cysts of the spleen from turned-in residues of the serous endothelia are found in frequent occurrence of real subserous epithelial cysts in the diaphragm and the epicardium, on the surface of the tubuli of embryonal genital residues in the liver, and lastly in that particular category of cortical cysts found in the adult ovary. The theory that small cysts of the spleen revert to the fetal period is accepted with great reserve, for it seems to many authors that the hypothesis of a defect in development were better restricted to the possibility of inclusion of germs of lymphatic vessels (lymphangioblasten, Otto, Müller), rather than of epithelial cells. No one, writes Pepere, has previously brought forth conclusive proofs in favor of a direct derivation of cysts from the endothelium of the perisplenium, through a defect of development with the demonstration of the germ cells included under the capsule, burrowing themselves in gradually, neither was it suspected that all serous cysts of the spleen, with or without protrusion of the pulp, were of one common origin. The persistence of imbedded cell germs among the cysts with pulp protrusion is of itself a fairly strong argument towards the grouping in one class of all sub-capsular cysts of the spleen. Pepere believes that he has arrived, from direct observation in man and animals, at the true relation between protrusions and cysts. His conclusions drawn from experiments lead him to consider protrusions of the pulp as an epiphenomenon of cysts not necessary but of frequent occurrence.

He has not found any ground for the acceptance of the mechanism, and the changes in the tissues which are set forth as arguments for the precedence of protrusions over cysts. He does admit that a proliferation allows the peritoneal endothelium, interrupted by the protrusion of the parenchyma, to reach the deep parts of the organ through fractures of the capsule. He grants, however, the formation of small pseudocystic cavities and of fragments of endothelium between the protruding tissue, but he regards these as mere accidents, which have nothing in common with true splenic cysts.

Once we have demonstrated the presence and origin of cell germs between intact perisplenium cysts and those with interrupted perisplenium and protrusion of the pulp and proved that the production of hernia of splenic parenchyma accompanying the cysts is secondary, it is easy to understand how findings can vary in each individual case. When there are formed only one or a few cysts from the groups of endothelia imbedded during development of the organ, the excavations resulting therefrom are unable to expand, and remain quiescent under the capsule and preferably in pre-determined places, but if the endothelial masses are numerous they will coalesce and damage the splenic tissue, in proportion to the number and size of the cysts.

In conclusion, Pepere states that all small cystic excavations of the spleen,

multiple or isolated, subcapsular or in the perisplenium, with or without protrusion of the pulp, known under the name of "multiple serous" or "subcapsular cysts," "cysts with protrusion," must be considered etiologically equivalent; they have as their only and common origin subcapsular endothelial nests or filaments which are residues of abnormal invaginations of the perisplenium and its serous membrane, or from an incomplete soldering of its connective endothelial layers at the bottom of the clefts during the development and growth of the organ; all the various connections between cysts and their various relations with the normal splenic tissue or with that which has protruded through capsular fraction (hernia of the pulp) are exclusively dependent on the growth of the cysts which through assuming many different forms have one and all the same anatomical significance.

2. POLYCYSTIC DISEASE.—Explanations thus far offered do not make clear the occurrence of extensive multilocular cyst formations. Renggli's theory of inclusions of peritoneum from superficial inflammation would not seem to hold good. A different explanation must be offered for the occurrence of countless fused cysts scattered throughout the organ. These are best explained by the dilatation of the blood or lymph sinuses. Although the intimate nature of these channels is not clearly understood, the origin of multiple, multilocular cysts has been attributed to the lymphatic system. We are indebted to Fink who first recognized this relation. He described several cases. Opinions in support of this origin are held by Kühme, Aschoff and Schmidt. The cause of lymphangiectasis is not clearly understood. In twelve cases which were thought to have originated in the lymphatic system various explanations have been offered. Lymphangiectasis may be due to mechanical conditions, or inflammatory processes. In no cases, however, has an interference with return flow been demonstrated, nor has there been any reason to suppose that an increased supply of lymph had resulted in this condition. Lymph stasis alone would not offer a rational explanation. The conglomerate and multilocular form which these cysts assume is to be explained by the fusion of individual dilatations. Some of these formations have been reported as lymphangiomas, but whether these are actually new growths or not is an open question. Misplaced lymph-vessels or their cells of origin might become snared off during fetal life, proliferate and form such a cystic growth. We know that the spleen is an important if not a vital blood-forming organ during the development period, and it would appear that extensive changes occurring at this time necessarily interfering with function would hardly permit of life prolonged to an adult age. This would speak against the congenital lymphangioma of the spleen. Fink was successful in proving histologically the transition of dilated lymphatic channels to large cystic cavities. No sharp distinction can be drawn between lymphangiectasis and lymphangioma. The one possibly represents a sliding scale into the other without a marked transition stage. It has been suggested by M. B. Schmidt that certain preformed canals existing in the peritoneal capsule and trabeculæ, which he believes are lymphatic spaces, may be from cysts. Schmidt holds in part in this connection to the Beneke theory

SURGERY OF CYSTS OF THE SPLEEN

of traumatic hernia of splenic tissue, but believes that lymph cysts develop in this manner from snared-off peritoneal endothelium, as well as multiple serous cysts. He has adopted this theory on the ground that some of the little superficial cysts show on their cut surface a cavernous structure and network of interlacing bands. Kühne and Jamischita believe that cysts may develop from these lymphatic spaces in peritoneal endothelium and trabeculae.

In twelve cases the diagnosis of lymphatic cysts or lymphangioma has been made in this series. In some instances findings are at variance with our conception of these cysts. In the case of lymphatic cysts resulting from lymphangiectasis, the organ is enlarged as a whole. Cönen has designated this condition polycystic degeneration. This has been described by Cönen and myself. The surface is irregular and the seat of countless projections. The cut surface shows innumerable cavities, some isolated, others confluent. The latter in their interior present an interlacing network giving the characteristic appearance of a multilocular cavity. The cyst walls in places may be in immediate contact or there may be a small amount of splenic tissue between them. Aspiration of these cavities before fixation of the organ and coagulation of their contents shows a fluid presenting the characteristics of lymph. It is usually clear, of high specific gravity and high percentage of albumin. After fixation this material coagulates into homogeneous masses which stain a pink color with eosin. Microscopic examination shows lymph or blood sinuses in various degrees of dilatation which range in size from the slightly dilated channel to large cystic cavities. The smaller cavities usually show no endothelial lining. The larger show a delicate connective-tissue wall and an endothelial lining which may show degeneration at various points. In some places it would appear that this lining has become retracted from the wall and adherent to the coagulated lymph. Cellular contents are usually present. Hemorrhages are prone to occur into the larger cavities. The above description would hold for a lymphangioma were the process a localized conglomerate mass such as Fink had described at the hilum of the spleen. In these cases the organ itself is not materially enlarged.

Efforts to determine the mode of origin through a study of the lining of cysts have not proved successful, for as Aschoff has pointed out, the character of the cellular lining is not proof of origin. Endothelium of lymph-vessels could be transformed into cuboidal epithelium. It would seem, however, that there is some evidence to substantiate the peritoneal origin in few individual cases.

Pepere believes that his general considerations presented above also hold good toward excluding the generally accepted lymphatic origin of cysts. He agrees with Schmidt and Müller that the lack of connection or continuity of cysts with the lymphatic vessels in the region, however, cannot constitute sufficient reason to exclude their origin from the latter. But it would seem strange in the case of excavations derived truly from lymphatic telangiectases, that even when fairly numerous these were not accompanied by changes in the neighboring lymphatic vessel. Pepere does not exclude the possible

formation of lymphatic cysts in the subcapsular portions of the spleen. But if the macroscopic appearance of these lymphatic cysts approached that of epithelial cysts of the spleen the histologic characters will usually refer them to their true origin. As to the neoformative cysts (Otto) Pepere believes it is easy to contend that among these can be included exclusively the lymphangiomatous forms.

Symptoms.—Clinically, the most frequently recognized cyst is the large unilocular variety of hemorrhagic or serous type containing one to ten litres. Intermittent or continuous extravasations of blood are never sufficient to cause symptoms of internal hemorrhage.

In general terms symptomatology is simple. In the absence of any apparent function of the adult spleen there are no symptoms which are present as the direct result of the involvement of the splenic tissue per se. When cysts are small there are no symptoms. The small cysts have been accidental post-mortem findings. Large cysts usually cause symptoms from pressure. A low grade inflammation causes adhesions, which in turn may also result in symptoms. Intense peritoneal reaction may excite severe pain, vomiting and fever. In not a few cases have acute symptoms brought the patient to the physician. The predominant symptom is pain. It may express itself as a feeling of heaviness and be of a dragging character. It is located in the left hypochondrium or referred to the epigastrium. A number of these cases have been mistaken for movable kidney. If the spleen is dislocated pain may be experienced in any part of the abdomen and radiate to the hypochondrium. The chief symptoms are from pressure. Digestive disturbances have been frequently observed as a result of this. The stomach and intestines suffer from disturbed function by being crowded downward and to the right. Dyspnoea and circulatory disturbances are more rarely present from upward pressure upon the diaphragm. Obstinate constipation has been observed, more rarely diarrhoea. Frequently the patient has first observed the presence of an abdominal tumor which has gradually increased in size without pain (Heautreaux, Monnier, Routier, Wells). Growth is usually slow. In other cases reported mild repeated attacks of pain or dyspepsia have been the rule, or a long latent period has resulted in a sudden severe outbreak. Occasionally symptoms of collapse have occurred from a twisted pedicle. Loss of weight and strength has not been observed until the growth is large.

The tumor is usually located to the left of the umbilicus. A cyst of large size may extend from the lower border of the ribs to the median line and below the navel. Percussion reveals a mass continuous with splenic dulness. The mass may be freely movable or fixed. The surface may be smooth, irregular, of doughy or elastic consistency. Fluctuation is not always present. Monnier has drawn attention to a friction sound which results from perisplenitis. It indicates the presence of adhesions and is of no special diagnostic value. There is usually no ascites except in the case of new growths.

Diagnosis of cyst of the spleen has rarely been made clinically. Many have been recognized post mortem. The previous history of the patient is of

SURGERY OF CYSTS OF THE SPLEEN

the utmost importance. Careful inquiry must be made in regard to trauma, the rapidity of growth, its situation when first observed, the direction of growth, and character and site of pain. The laboratory, X-ray and ureteral catheterization may be useful in excluding other conditions. The most decisive symptom is the discovery of a tumor in the left hypochondrium which presents the characteristics of a cyst. Other abdominal cysts are of more frequent occurrence and must be excluded before a cyst of the spleen may be diagnosed. The diagnosis of enlargement of the spleen only may be made. It is usually not difficult. Blood examination is here of great help. It may not be possible to appreciate the fact that the tumor is cystic. Puncture through the abdominal wall for diagnosis is never justifiable. All other common causes for splenic enlargement must be ruled out. A more refined diagnosis than that of abdominal cyst or splenic enlargement can rarely be made. Cysts of the spleen must be differentiated from cysts of the omentum, pancreas, mesentery, and left lobe of the liver. If the cystic spleen is displaced into the pelvis, it may be easily mistaken for an ovarian cyst or floating kidney. Adhesions may occur between the uterus and the dislocated spleen and further simulate tumors of adnexal origin.

Treatment.—Cysts of the spleen have been treated surgically by (1) puncture, (2) incision and drainage, (3) excisions of the cyst and by (4) splenectomy. The less radical procedures were undertaken at a time when splenectomy was considered a grave operation, and before it was clearly demonstrated that removal of the spleen was not followed by serious impairment of the general health. Eight cases received treatment by puncture. In this series diagnosis of the character of the cyst was dependent upon the examination of the aspirated fluid. Four of these were said to have recovered. One death was caused by operation. It was due to peritonitis and followed the injection of iodine. Reaccumulation of fluid took place in two cases. The fourth case which remained uncured resulted in a persistent sinus. Puncture and subsequent injection does not afford a complete cure and is a dangerous, unsurgical procedure. Within recent years it has not been performed. The last time was in 1898, by Reimann. His patient refused more radical treatment.

Fourteen cases were treated by incision and drainage. The result is unstated in five cases, seven recovered, two died. Healing has been protracted and occurred in from three months to one year. Causes of death were sepsis (Powers) and peritonitis and splenitis (Quintard and Pean). This method has been preceded in a number of cases by exploratory puncture before laparotomy. Various methods of drainage have been used, tampons in two cases, marsupialization in three. A two-stage operation has been performed. Following laparotomy and the establishment of adhesions between parietal peritoneum and cyst wall, incision is made and contents drained. This is an advisable procedure in case of parasitic cysts if no more radical treatment is possible.

Excision of the cysts has been practiced six times. Four recovered, one died, result unstated in one. The cause of death in Bircher's case was post-

operative intestinal obstruction from pressure by the spleen. No difficulty may be encountered in excising the walls of the cysts if it is subcapsular. Radical treatment of the floor of the cyst may be effected by cauterization (Bardenheuer). Hemorrhage may be controlled by clamping at the hilum. Partial splenectomy (excision of the cyst-bearing tissue) is rarely justifiable. This procedure is attended with grave danger from hemorrhage. It has been accomplished by Bircher, who controlled hemorrhage by interrupted sutures placed around the cyst. It has been successfully performed by Gussenbauer. It must be regarded as a very formidable operation, as these cysts are rarely, if ever, pedunculated.

Splenectomy is the treatment of choice in cases in which the operation is not contraindicated by the presence of extensive adhesions. In selected cases permanent recovery may be secured by less radical means. If there is polycystic degeneration (Cönen, Fowler), or if the spleen is otherwise extensively affected by preëxisting disease (malaria), or if the spleen is materially enlarged as a result of the cyst, if there is displacement, elongation of the pedicle with danger of torsion, excision of the spleen is the best treatment.

Pean was the first to perform splenectomy for cyst (1867). Johnson, in an admirable monograph upon splenectomy, has collected from various sources nineteen cases of cysts which were treated in this way without mortality. All these cases occurred prior to January, 1908. Three cases in Johnson's series are not included in my list of splenectomy cases (Baccelli, Israel and Gerard). The case of Hedinger, reported in 1906, was overlooked by Johnson. In all I have been able to obtain complete satisfactory data of thirty cases of non-parasitic cystic spleen treated by splenectomy up to 1921. (Excluding Case I, Hamilton and Boyer, those of Baccelli, Israel and Gerard.) The operative result is not stated in two cases (Royster, Boechelman). One died, Homans (angio-sarcoma?); twenty-seven recovered.

Parasitic Cysts.—Parasitic cysts are uncommon. Echinococcus is the most frequent variety and occurs in regions where hydatid disease prevails. The spleen was involved in 2 per cent. of cases of hydatid disease which Thomas studied. He collected eighty-eight cases in which the spleen was affected. In forty-five of these the spleen alone was involved. Solitary cysts are very rare. They may be unilocular or multilocular, single or multiple. They may be situated anywhere in the organ. The mode of entrance of echinococci into the spleen is interesting. Leukart has found them in the portal circulation, which explains their entrance into the liver. This is the site of predilection, but to gain entrance into the spleen by this route the embryos would have to go against the blood stream. A possible explanation is that after being freed from the capsule by the action of the digestive juices they traverse the gastric and intestinal walls by boring or pushing their way directly into the spleen where this organ is in relation with the stomach and colon. They may push their way through potential spaces, or they may travel in the lymphatics. The extreme rarity with which the embryos are found in the lymph-glands and vessels speaks against lymphatic transference.

SURGERY OF CYSTS OF THE SPLEEN

The first splenectomy for echinococcus disease of the spleen was performed by Koeberle in 1873 and ended fatally. The second splenectomy by Bergman recovered.

Mosler collected thirty cases of hydatid spleen in 1884. Twelve of these were collected from post-mortem statistics. Eighteen cases were diagnosed during life.

Two cases were reported by FEHLEISEN before the Berlin Surgical Society. The first was a female, aged thirty-eight years. The tumor was of sixteen months' duration. At first it was the size of a fist, movable under the ribs on the left side. It continued to increase in size. Pain was felt in the left hypochondrium and radiated to the lumbar region. At one time it was diagnosed as ovarian tumor with long pedicle. When first seen by Bergman she had a fairly movable tumor with indistinct fluctuation the size of a man's head, occupying the left side of the abdomen. Exploratory puncture gave a clear fluid containing hooklets. Examination under anæsthesia showed the tumor was not connected with the genitals, liver or kidneys. Bergman performed splenectomy. There were numerous adhesions to the intestines and mesentery. Recovery.

The second case occurred in a male, aged eleven years, who for three years had lancinating pain in the splenic region and for one year a painful tumor. Pains increased, tumor grew to size of an orange, distinct fluctuation. Diagnosis, hydatid spleen. Confirmed by puncture, marsupialized. Recovery.

EDMONDO COEN reports three cases observed at autopsy. The first was a man aged seventy years who died of marasmus. A solitary echinococcus cyst divided the organ into two separate segments, which were completely separated from one another. The second case occurred in a male, aged forty-six years, in which death occurred from meningitis. The solitary echinococcus cyst occupied the concave surface and was deeply sunken in the parenchyma and covered by a firm, partly calcified, capsule. The third case reported was in a male, aged forty years, in whom death occurred from cardiac insufficiency. Echinococcus was located on the convex surface of the spleen. Echinococcus of the liver was also present.

Males seem to be more disposed to this disease than females.

Symptoms.—For the most part symptoms are due to pain from increased growth and pressure. In the abdomen symptoms are referred to the stomach, intestines or ureter, in the chest to the lungs and heart. In none were there symptoms present indicative of splenic affection during life.

Up to 1890 the literature records fifty-eight cases of solitary echinococcus cysts, forty-two in which other organs were affected.

Spontaneous recovery has occurred from calcification of the parasite. Berthelot reports a case which ruptured into the intestines in which 1200 vesiculæ were discharged per rectum with recovery. Recovery has also followed rupture into the air passages. Death follows rupture into the peritoneal cavity.

Johnston, writing in 1908, quotes Bessel Hagen as having collected fifteen splenectomized cases of hydatid diseases of the spleen up to 1900. There were four deaths. Johnston collected eight additional cases from the literature reported by Carnabel, Delore, Von Herczel, Jordon, Latarget, Slavchev Tricome and Gainnettasio up to 1908 with no deaths. The mortality for the twenty-three cases is about 17 per cent.

SUMMARY

1. There are two authentic cases of dermoid cysts recorded.
2. These studies include ninety cases of non-parasitic cysts of the spleen, representing a variety of types due to various causes classified as true and false, depending upon their mode of origin.
3. Non-parasitic cysts are most common in women during the child-bearing period.
4. Pregnancy and such antecedent diseases of the spleen as malaria and syphilis can not be evoked for more than minor contributing rôles.
5. In the case of pseudocysts, trauma plays the most important rôle in the simple, large, unilocular, so-called hemorrhagic or serous type; the latter usually develops secondarily from the former.
6. The influence of twisted pedicle, embolism and disease of intrasplenic blood-vessels cannot be denied.
7. In the case of true multiple cysts, inclusions of misplaced cellular nests (endothelium of the peritoneum or cells of origin of lymphatic spaces or vessels) during the developmental period, or as a result, in later life, of traumatic or spontaneous rupture of the capsule or of perisplenitis, may result in multiple cysts of the serous or lymphatic variety.
8. True neoformative cysts (lymphangioma hæmangioma) are not common.
9. Sixty cases of non-parasitic cysts have been treated surgically, eleven by puncture, fourteen by incision and drainage, six by excision or partial splenectomy, thirty by splenectomy. The latter is usually the method of choice. The mortality for splenectomy is 3.5 per cent.
10. Echinococcus disease of the spleen represents the one type of parasitic cysts reported in the literature.
11. This disease is rarely a surgical problem of the spleen alone, for in about four-fifths of the cases the liver or other organ is involved. There are about one hundred recorded cases up to 1890. The mortality for twenty-three cases subjected to splenectomy up to 1908 is about 17 per cent.

TECHNIC OF NERVE SURGERY

By K. WINFIELD NEY, M.D.,
OF NEW YORK, N. Y.

FORMERLY CHIEF OF THE NEURO-SURGICAL SERVICE, GENERAL HOSPITALS, NO. 3 AND NO. 41, UNITED STATES ARMY.

THE presentation of a paper on the operative treatment of peripheral nerves quite naturally calls for an introductory exposition of the physiology and histology of the normal peripheral nerve and of the histopathology and pathological physiology of peripheral nerve tissue when visited with disease or subjected to injury; for it is only on the basis of a thorough understanding of these histological and physiological principles that rational operative treatment can be applied. Fortunately, these principles, placed upon a sound footing more than two decades ago, have been amply verified by subsequent experimentation and consistently upheld by the innumerable clinical observations afforded by the vast amount of clinical material supplied by the battle casualties of the World War. The conclusions arrived at by Howell and Huber, in 1891, in their many experimental studies of peripheral nerve physiology, degeneration and regeneration, may still serve as text for a rational system of procedure in the operative treatment of peripheral nerves.

It would be needless to here attempt to recite these several principles, so oftentimes repeated in literature on peripheral nerves. It would best suit our purpose to interpolate these principles or deductions therefrom in places where they may best subserve the function of authority for steps advised, as we proceed in our discussion, for application in operative procedures on peripheral nerves. Having had within the short span of fourteen months over fifteen hundred peripheral nerve cases under my immediate care, of which I personally attempted operative procedure in about three hundred, I was afforded as intensive an experience in this field of surgery as has fallen to the lot of but few surgeons in the United States. Under the circumstances I feel that it would in no sense be an imposition on my colleagues to present on a basis of this experience a system, if such it may be called, of procedure and technic in the operative treatment of peripheral nerves.

Primarily, the necessity of surgical intervention can be determined only by the deductions made from several comparative clinical examinations. The operator should always have for his immediate information in the operating room a complete summary of the clinical findings, and the operative procedure should be governed by these clinical indications. This is particularly true in partial nerve lesions where a failure to observe and comply with these physiological indications has often been responsible for results not entirely satisfactory.

Anæsthetic.—Local anæsthesia has supplanted all other forms of anæsthesia in this clinic. It is of particular value in that analgesia is induced and motor power is retained. The technic of producing anæsthesia consists in a careful intradermal injection of the line of incision and a subcutaneous and deep infiltration of the operative area with a 1 per cent. novocain solution containing 15 drops of adrenalin chloride (1:1000) to each 30 c.c. of solution. Since almost all nerve exposures are through scar-invaded tissues, this type of anæsthesia eliminates to a remarkable extent the constant oozing encountered in scar-tissue dissections. With the completion of the operation and the passing of the temporary hæmostatic effect of the adrenalin, clotting has occurred at many oozing points where ligation would be difficult. These factors are of no small importance in the delicate dissections required in nerve surgery of scar-invaded regions, where dissections at best are difficult and time consuming, and in a bloody field almost impossible. During the operation all exposed tissues which are not receiving immediate attention are protected with hot saline sponges. Before closure is begun perfect hæmostasis is secured and all blood-clots are washed from the recesses of the wound. Great care is used at all times to prevent wound contamination by the covering of skin edges and exposed skin surfaces. A "non-touch" or purely instrumental technic is used throughout.

A practical anatomical knowledge is essential to nerve surgery in order that incisions may be made to the greatest advantage; it is also indispensable for careful dissection, since tissues should be traumatized as little as possible. Dissections should always be carried along anatomical planes, following lines of cleavage, when possible, advancing from the normal anatomy to the pathological. The exposure of the nerve should be made some distance above and below the lesion where its course and position are not distorted by scar tissue and where normal anatomical relationships prevail. Greatest care should be used in all dissections to prevent injury to nerve branches, and these accidents are best avoided by an accurate knowledge of their location.

Torsion.—Torsion of a nerve trunk is a serious eventuality in nerve suture; its prevention, therefore, is an essential factor in the ultimate success of nerve suture. Most peripheral nerves are mixed in function; certain funiculi subserve the function of motion, while others that of sensation. Twisting of the nerve trunk during its approximation by suture would effect a physiological misplacement of fibres—sensory fibres may be directed down motor channels and motor fibres through sensory pathways—thus resulting in a physiological loss; i.e., defective sensory return and a diminution in motor restoration. We do not believe that a physiologically misdirected nerve-fibre can reëducate itself to a totally different function; nor does the evidence at our command indicate that the directing sheath cells of the different channels have the power of discriminating between motor or sensory fibres in regeneration. [NOTE: In several musculospiral paralyses in

TECHNIC OF NERVE SURGERY

which suture was done, we have noticed a very defective return of both motor and sensory function. In each case formication was elicited with considerable intensity over the posterior interosseous nerve (the terminal branch of the musculospiral which contains mostly motor fibres), and almost complete absence of formication in the radial nerve (the terminal branch of the musculospiral nerve which is composed entirely of sensory fibres). The areas of anæsthesia in these cases after more than eighteen months show but little contraction. The muscles on the dorsum of the forearm retain their atrophy, loss of galvanic and mechanical irritability, but percussion of these muscles produces intense tingling which is localized in the musculospiral cutaneous anæsthetic area. These are instances which indicate a physiological misplacement of sensory and motor fibres.]

The prevention of torsion in nerve suture may be attempted by several different methods, all of which have been used at various times in this clinic: (1) *Identification sutures*. (2) *Funicular or bundle matching*. (3) *Forceps identification*. (4) *Anatomical or striation markings*. Identification sutures consist of placing a fine silk suture in both segments of the nerve proximal and distal to the lesion and at a definite point in its circumference before it has been completely dissected from its bed. When the nerve is ready for approximation the identification sutures are lined up so as to prevent any twisting of the nerve trunk upon its axis. These identification sutures should be placed in the nerve sheath where it lies in a normal position, far enough away from the scar tissue to avoid any torsion which might be caused by cicatricial contractions. Occasionally, two identification sutures are placed on both proximal and distal segments to insure a more perfect alignment.

2. *Funicular or bundle matching* would be satisfactory to a high degree if it were possible to identify the physiologically different funiculi in both ends of the divided nerve, but this is impossible in the upper end, and in the lower end the physiologically active element—the neuraxon—is missing. The bundles found on sectioning the proximal segment of the nerve do not, as a rule, correspond, either in number or size, with those of the distal segment; therefore, we have not been able to match bundles with any degree of success.

3. *Forceps identification* has been very satisfactory in our experience, because the forceps are readily adjusted and very convenient for holding the nerve for section and later for suture. With fine mosquito forceps the sheath is grasped on either side of the nerve trunk as it is lifted from its bed. Placed on both upper and lower segments these forceps serve the twofold function of surface identification and fixation.

4. *Anatomical markings* are of value in that observation of the longitudinal striations will often serve to reveal a twisting of the nerve trunk. The course of blood-vessels will frequently give the same information. The shape of the nerve where it is flattened, as is the external popliteal near the head of the fibula, may serve to reveal torsion. No one of these methods should be used independently, but in the various regions each will serve a definite purpose, and one may be used as a check upon the other.

Nerve Defects.—When the nerve has been dissected free from the scar tissue (which usually infiltrates the region of the injury and often extends some distance up and down the nerve trunk) the end of the proximal segment is usually found to present a neuroma. The end of the distal segment seldom reveals any enlargement, but more often is found terminating in the scar tissue from which it is often impossible to be differentiated. The upper segment should always be completely dissected first so as to expose the neuroma; the presence of a neuroma indicates that there has been a primary division with defective degeneration, while its absence suggests rather a physiological interruption-compression or strangulation which may not call for resection and suture.

When the nerve is found to be completely divided, the indications are for the resection of the neuroma and scar tissue from its end until normal-appearing nerve bundles are found; but before these resections are made, the extent of the nerve defect should be noted and the means necessary for its correction considered, bearing in mind that a resection preparatory for suture will probably increase the defect from 2 to 5 cm. and sometimes even more. The operator can often judge the amount of tissue which will have to be sacrificed in sectioning by the appearance of the nerve trunk and the degree of cicatricial infiltration manifest on palpation.

Nerve defects may be overcome by one of the following methods, or by their combination, i.e.: (1) *Primary stretching*. (2) *Flexion relaxation*. (3) *Transposition*. (4) *Two-stage operation*. (5) *Grafts*.

1. *Primary nerve stretching* alone will overcome a certain number of defects. It is best accomplished by placing forceps on each end of the unsectioned nerve and by exerting gentle traction drawing the ends together. The nerve trunk should be entirely freed from the surrounding scar tissue, and occasionally, to obtain the maximum benefit of stretching, it must be freed for some distance above and below the original exposure. We do not believe that the stretching of a nerve seriously interferes with regeneration; it is, however, always advisable to eliminate as much tension as possible from the suture line by the various methods herein suggested.

2. *Flexion relaxation* is used in most cases and has proved itself of greater value than any other one method in overcoming nerve defects; it is the secondary rather than primary stretching which is utilized in this procedure. The nerve is relaxed by flexion of the governing joint, which will often permit the overcoming of a considerable defect from 5 to 10 cm. As in stretching, it is necessary to free the nerve for some distance beyond the lesion, and, also, beyond the governing joint. After the nerve ends have been approximated by suture the limb is maintained in the flexed position by plaster or a special splint for four weeks, relaxing the nerve as much as possible, after which time extension of the extremity is gradually encouraged (secondary stretching) by adjusting the splint to permit about ten degrees of increased extension each day until the limb is completely extended.

3. *Transposition of nerve trunks* from a deep to a superficial plane, or

TECHNIC OF NERVE SURGERY

from an extensor surface to a flexor surface will assist materially in overcoming certain defects. In all transpositions greatest care should be exercised in the preservation of branches; these usually have to be isolated and freed for some distance up the nerve trunk in order to make the transposition possible without tearing or overstretching them (Fig. 1). Transposition is

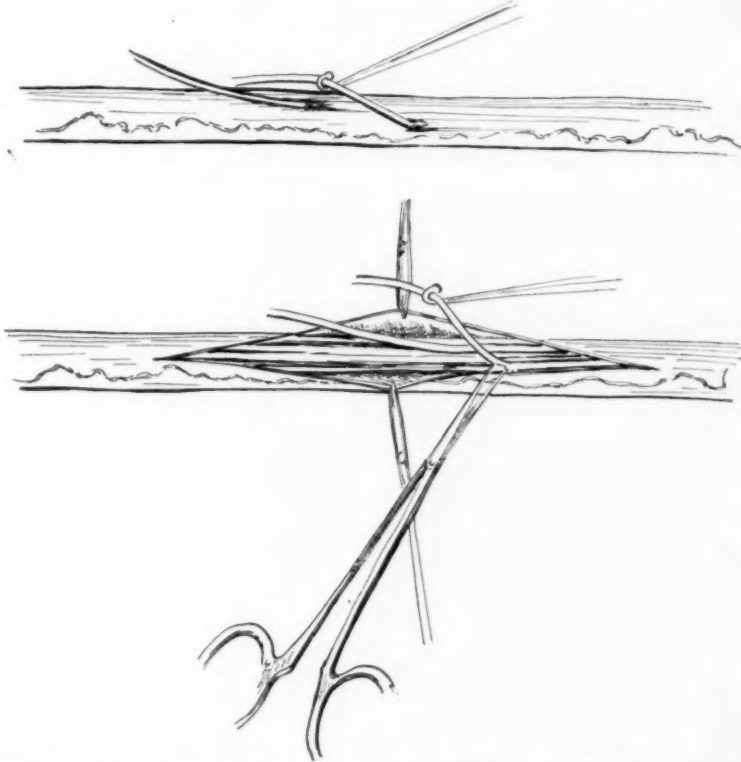


FIG. 1.—Method of mobilizing branches, usually found necessary before transposition of a nerve in the overcoming of large defects.

most advantageous in overcoming defects in the following nerves: (a) *Ulnar*, in lower arm or upper two-thirds of forearm, by transposing it from behind the internal epicondyle of the humerus to a position anterior to the internal condyle (Figs. 2, 3, and 4). (b) *Median*, lower third of arm or upper two-thirds of forearm, by transposing it from the deep position under the superficial head of the pronator radii teres to the more superficial position above this muscle (Figs. 5, 6, and 7). (c) *Musculospiral*, by transposing it from its position in the musculospiral groove on the posterior surface of the humerus to the anterior aspect of the arm where it is made to pass between the biceps and brachialis anticus (Figs. 8 and 9).

In each instance it is necessary to carry the dissection of branches some distance up the nerve trunk before transposition is possible. This is accomplished by gently lifting the branches from the trunk on fine glass hooks,

opening the nerve sheath and following the branch intraneurally, separating the funiculi with fine sharp-pointed iris scissors; the closed blades are passed between the bundles in the loose perifunicular connective tissue and gentle spreading makes the isolation of individual funiculi forming that branch a very simple procedure. Frequently a single branch may be followed 5 to 10 cm. up a nerve trunk.

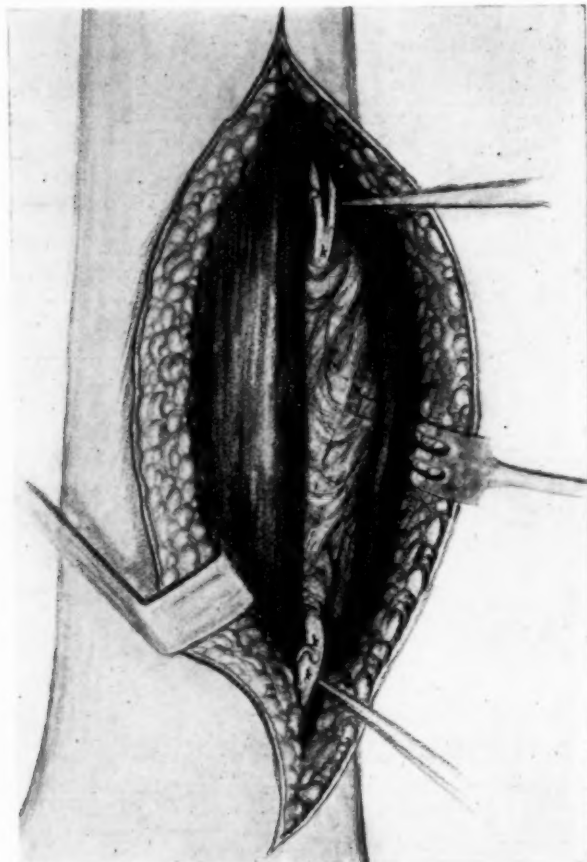


FIG. 2.—Ulnar nerve showing scar tissue as found at operation. Exposure of distal and proximal segments and placing of identification sutures.

4. A *two-stage operation* is used only for large defects which cannot be overcome by the usual methods, such as immediate stretching, flexion-relaxation, transposition, or a combination of these methods.

The *first stage* of the operation consists of the usual exposure of the nerve, placing of identification sutures in its sheath for subsequent alignment and freeing it from the surrounding scar tissue. The ends of the nerve are approximated as nearly as possible by flexion-relaxation and stretching; several heavy silk sutures are passed through the scar tissue and neuromatous

TECHNIC OF NERVE SURGERY

ends of the freed nerve (the scar tissue and neuroma are allowed to remain on the ends of the dissected nerve to permit of greater traction); these sutures are tied, placing the nerve under as much tension as is necessary to correct the defect; the wound is closed and the limb retained in flexion for one week, after which the fixation apparatus is removed and extension encouraged. Complete extension should be accomplished by another week, when, if there has been no infection and the skin is in good condition, the second stage is

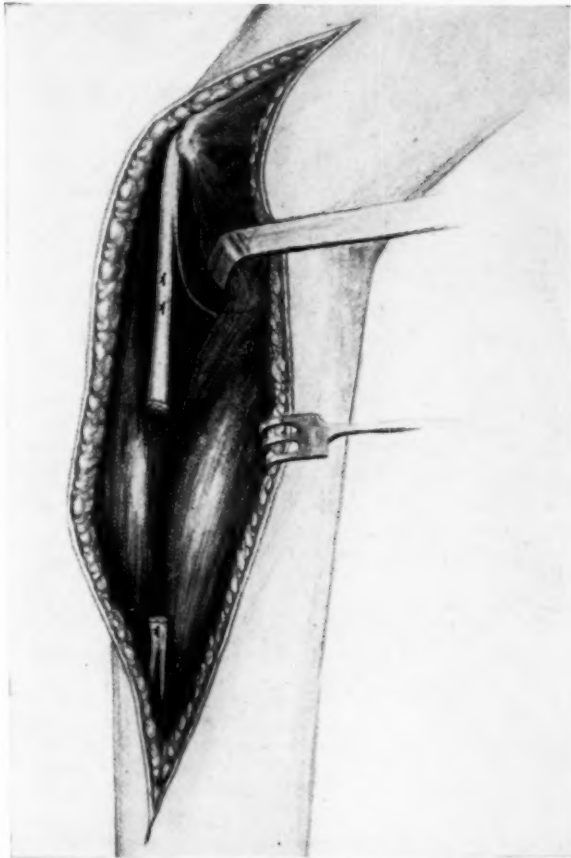


FIG. 3.—Ulnar nerve, second stage, showing amount of defect after nerve is sectioned. Incision extended upward above the internal epicondyle to permit transposition.

possible. The *second stage* consists in exposing the stretched nerve which will usually be found elongated sufficiently to permit resection of neuroma and scar tissue; and approximation and suture is accomplished by again flexing the governing joint. The limb is retained in flexion, this time for four weeks, as in the flexion-relaxation method, after which it is slowly allowed to extend. The two-stage operation has, in my experience, almost eliminated the necessity for grafts and has, on several occasions, been successful where grafts had failed.

5. *Grafts*.—In the past, various types of operations have been suggested for the overcoming of nerve defects, and not a few of these were doomed to failure because the fundamental principles governing nerve regeneration were ignored. Essential to the regeneration of the neuraxon is the directing activity of the cells of the sheath of Schwann in the distal segment. These cells are essential to regeneration, as they seem to possess the function of directing the outgrowing neuraxon into the channels of the distal nerve trunk. The interposition of any foreign material acts only as an additional barrier.

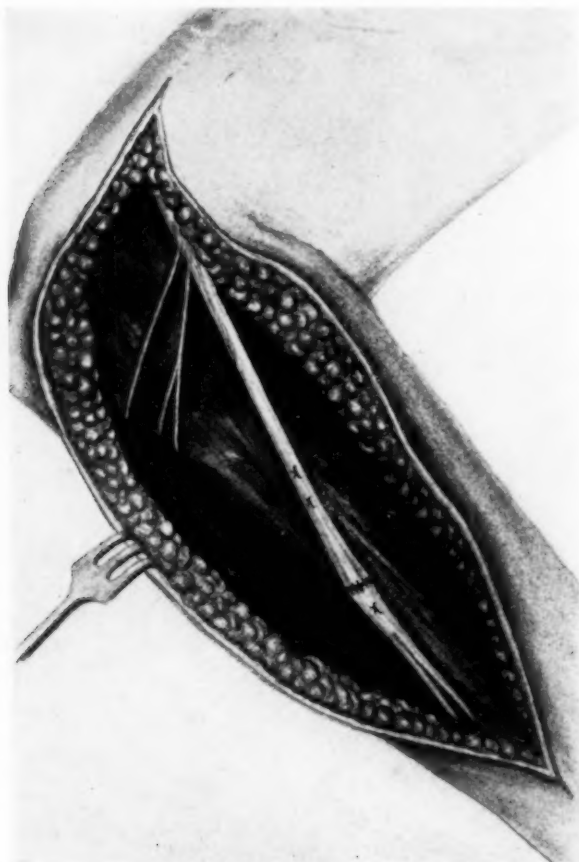


FIG. 4.—Ulnar nerve, third stage; defect overcome by transposition. Branches supplying the flexor carpi ulnaris and flexor profundus digitorum preserved by mobilization after opening the nerve sheath.

The success of grafts depends upon the activity of these living sheath of Schwann cells, and our experience seems to indicate that they should be fresh homo-grafts, or, better, auto-grafts. We have used several homo-grafts, refrigerator stock, but in none was regeneration satisfactory. In each case we subsequently removed the graft and repaired the nerve defect by the two-stage operative technic. The auto-graft, however, has proved partially suc-

TECHNIC OF NERVE SURGERY

cessful in several instances, in my experience, but it has certain obvious disadvantages. In this procedure a sensory nerve is selected, such as the



FIG. 5.—Median nerve exposed in forearm, first stage; a large defect below the pronator radii teres. Identification sutures placed. Sensory portion of musculocutaneous nerve crossing upper portion of operative field.

sensory portion of the musculocutaneous in the leg or arm, or the radial branch of the musculospiral. These nerves are usually small and several strands are often required in bridging the defect in order to approximate in

size the nerve to be repaired. In order to do this the strands are arranged in bundles (Fig. 10) and then inserted between the ends of the defect after the

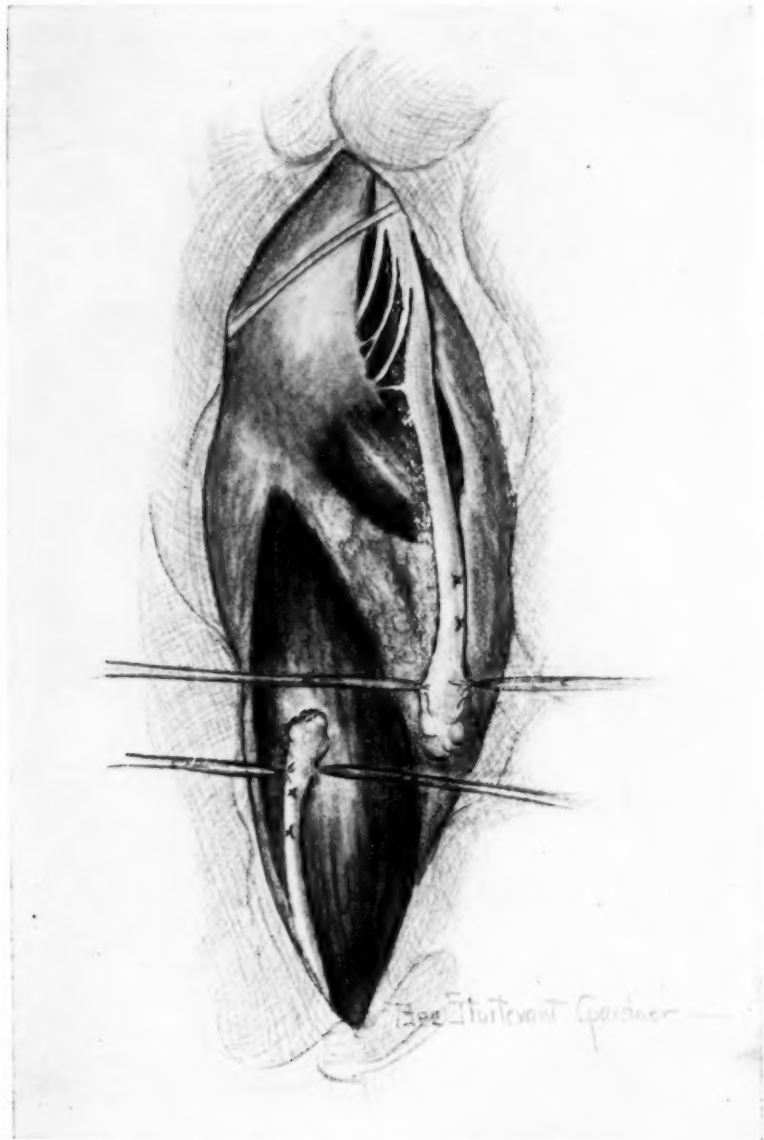


FIG. 6.—Median nerve, second stage; nerve transposed superficially to the pronator radii teres by opening the sheath and mobilizing branches in the upper part of forearm, making transposition possible from its deep position to a superficial position.

manner of ordinary suture. Our experience has led us to believe that, as a rule, nerve grafts are not entirely satisfactory, therefore at the present time we resort almost entirely to the two-stage operation previously described when the defect is too great for end-to-end suture at the primary operation.

TECHNIC OF NERVE SURGERY

Preparation of a Nerve Bed.—When scar tissue is prevalent we endeavor to transplant the nerve and obliterate the old bed. The preparation of the new bed in a neighboring healthy muscle is, as a rule, only fairly satisfactory, and it is much more desirable to transplant it in an adjacent scar-free inter-muscular plane. Frequently we find it is preferable to bring the nerve to a superficial position where it is covered only by the subcutaneous fat, which,

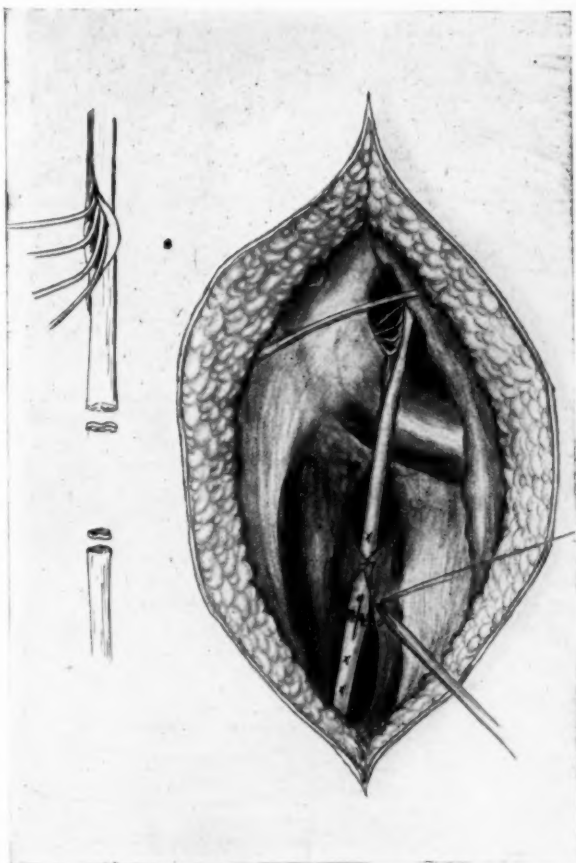


FIG. 7.—Median nerve, third stage; large defects overcome by transposition of the median nerve to a superficial position above the pronator radii teres.

if abundant, forms an excellent protection. It is advisable after preparing the new nerve bed to secure complete hæmostasis before attempting nerve suture—certainly before approximation if the nerve is under tension and the adjacent joint is to be flexed. Foreign tissues such as fascia lata, veins, Cargyle membrane, tubes, etc., are never used by us to protect the suture line; we believe that they are productive of more harm than good. Scar tissue will reform in spite of anything we can do and it can only be diminished by *perfect hæmostasis, a minimum of tissue trauma, and an aseptic technic.*

Nerve Suture.—The preparation of the nerve ends for suture consists in the resection of the neuroma and scar tissue by removing thin cross sections (Fig. 11) until normal-appearing bundles are found throughout the sectioned



FIG. 8.—Showing the effect of transposition of the musculospiral nerve from its posterior position behind the humerus to an anterior position between the biceps and brachialis anticus.

end. We usually keep the sectioned portion of the nerve bathed with a fine stream of saline solution to wash away the blood and permit an unobstructed observation of the sectioned surface. In making these sections it is important

TECHNIC OF NERVE SURGERY

that the nerve be steadied by two or more fine forceps which grasp firmly the nerve sheath near the point of section (Fig. 12). A safety razor blade manipulated through a firmly applied forceps is an admirable instrument for use in sectioning the nerve. When it is not necessary to sacrifice too much tissue it is advisable to remove sections until the nerve sheath, as well as the trunk, is free from scar tissue, because the presence of a scar infiltrated nerve sheath is often responsible for subsequent contractions and constriction of the

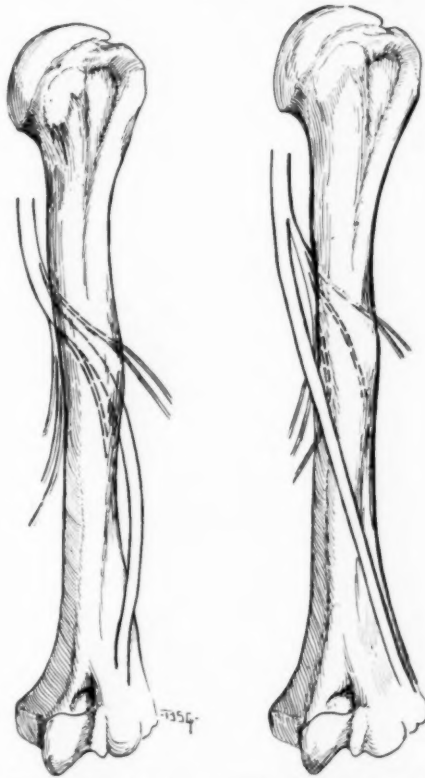


FIG. 9.—Showing the course of the musculospiral nerve and the relation of the branches to the triceps as it passes behind the humerus to the musculospiral groove; and the preservation of branches in transposing this nerve to the anterior position.

regenerating fibres. When normal-appearing bundles are found, and the nerve sheath presents considerable thickening for some distance—too far to justify a sacrifice of the entire nerve trunk—it is advisable to complete the suture, and after perfect approximation is obtained, split the nerve sheath longitudinally through its infiltrated portion. Occasionally it is necessary to leave some scar tissue on the sheath to facilitate suture when under tension, the scar tissue permitting greater traction; this, however, is only justified by necessity. When the distal end of the nerve is smaller than the proximal segment, it is often necessary to make a diagonal, or a "V" shaped (Figs. 13 and 14)

section of the small end to insure perfect approximation of the sheath in suture. Defective sheath approximation is often responsible for imperfect functional return, in that certain axis cylinders wander outside the sheath, are caught in scar tissue and lost; it is also responsible for sensitive neuromas forming at the suture line. The *suturing* is accomplished by fine silk epineural sutures; usually eight are required. These sutures completely penetrate the nerve sheath and to a very slight degree the perifunicular connective tissue. The sutures are arranged in such a way as to insure as near perfect alignment

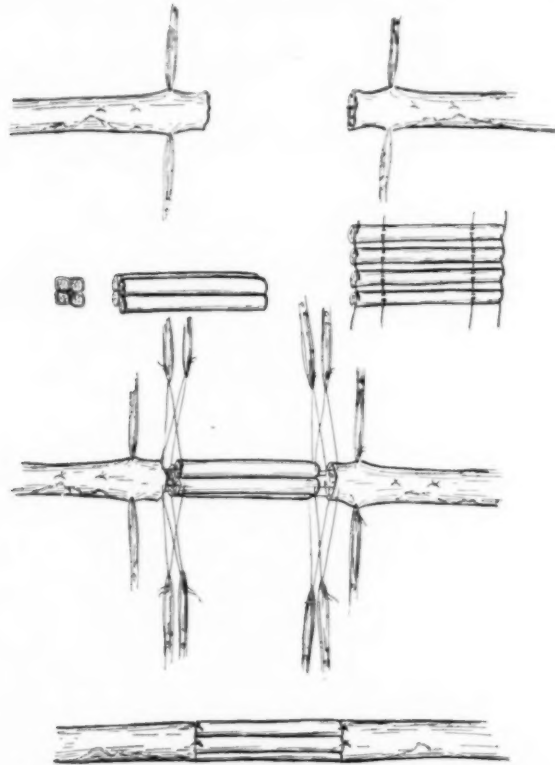


FIG. 10.—The bundle or "cable" shaft, using an auto-sensory nerve for repair of the defect.

as possible. They are placed in a definite order (Figs. 15, 16, and 17) and not tied until all are inserted. Each suture as placed is grasped with fine mosquito forceps and held in this manner to act as a guide suture for the placing of the next. Four sutures are placed in the four quadrants of the nerve sheath—the fourth being placed on the posterior surface by rotation of the nerve trunk on its axis by means of the other sutures. When the quadrant sutures have been placed, the identification forceps are removed from the nerve sheath and intermediate sutures placed between the quadrant sutures. At the placing of each suture all other sutures are kept taut, thus stretching the nerve sheath in a manner similar to that used in blood-vessel suture.

TECHNIC OF NERVE SURGERY

When tension is encountered in overcoming the defect a tension suture is indicated. This consists of a No. 0 plain catgut suture passed completely through the nerve trunk about one cm. from the epineural sutures (this is placed while the epineural sutures are held taut and in such a manner as to insure alignment). When all sutures have been placed the governing joint is flexed, and the tension suture is gradually tightened until the nerve ends are approximated, after which it is tied and cut. The epineural sutures are then tied and the suture line carefully inspected by rotating the nerve trunk. Extra epineural sutures are used if approximation of the sheath is not perfect at all points. While the approximation sutures are being tied the ends of the nerve are carefully washed free of blood-clots to prevent, as much as possible, the formation of scar tissue within the nerve trunk at the line of suture.

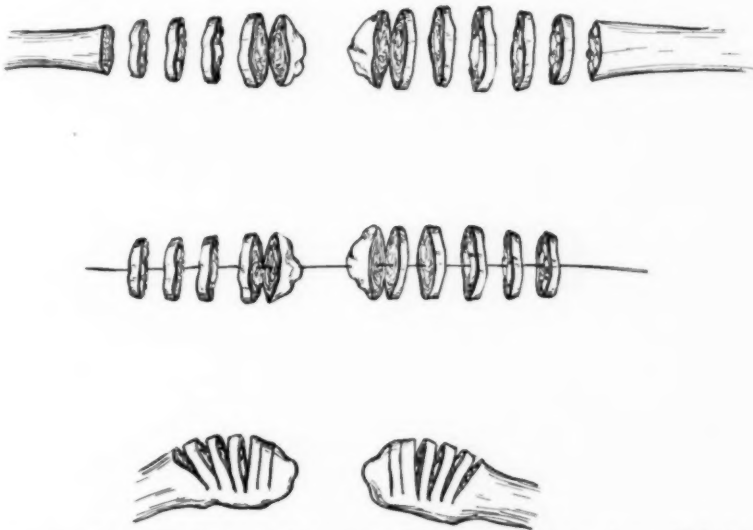


FIG. 11.—Sectioning of nerve ends for removal of neuroma and scar tissue. Method of preserving sections in order of removal.

Partial Suture.—Frequently a nerve may present only a partial neuroma and faradic stimulation at the operating table may indicate that a portion of the nerve carries impulses; this is usually confirmed by the pre-operative clinical reports which note the presence of voluntary power, faradic irritability, etc., in some of the muscles supplied by the injured nerve. Partial interruptions are common in sciatic lesions where those fibres which make up the external popliteal portion are far more frequently involved (Fig. 18). The identification of the two terminal branches of the sciatic nerve is often possible even as far up as the gluteal region, and in such cases the problem of preservation of the physiologically active portions is quite simple, but it is more difficult when the anatomical identity of the individual components are lacking. In the latter cases, in order to prevent injury to intact funiculi, we have found it expedient to resort to an intraneural procedure (Figs. 19 and 20). The

nerve sheath is opened and the line of cleavage between the two segments is looked for; failing in this the individual bundles are separated and each subjected to a very weak faradic current, using a bipolar electrode—in this way the physiologically active funiculi may be readily determined. The funiculus to be tested is gently lifted on a glass hook to prevent diffusion of the current to other fibres. When an individual funiculus fails to respond to faradism it is traced to the point of injury where its division is demonstrated.

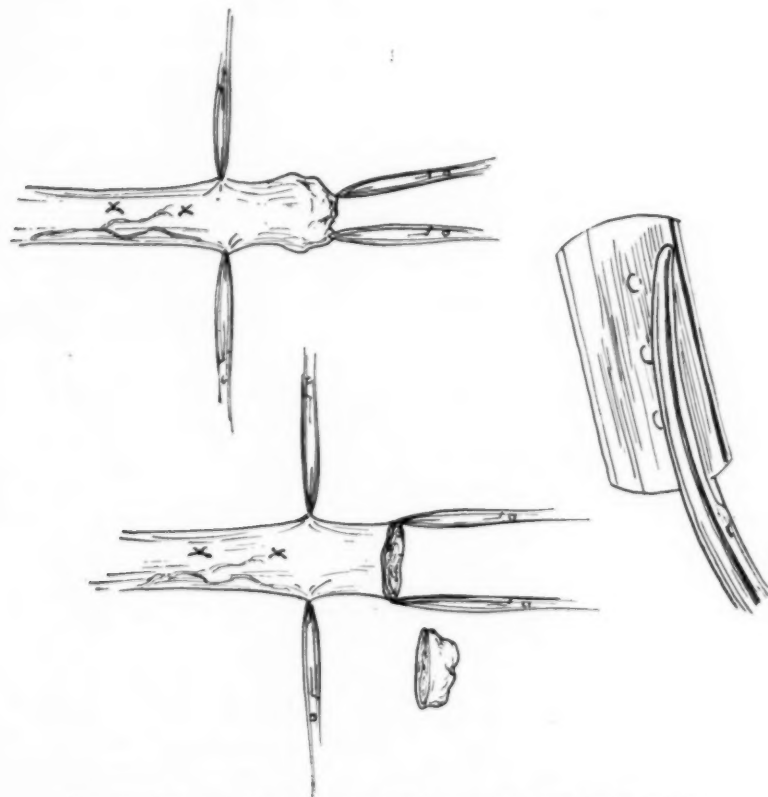


FIG. 12.—The application of forceps to an immobilized nerve during section.

Those funiculi which conduct faradic impulses are also followed past the point of injury so that they may be properly protected during suture of the divided funiculi. When it is necessary to make this type of suture the technical difficulties are greatly increased; the funiculi will stand but little tension, and consequently we find it advantageous to resect a portion of the sheath, and with its approximation the individual funiculi are brought in close apposition and retained by a fine suture of arterial silk either through the funiculus or including only the perifunicular fascial tissue. This type of suture is not unusual and is being constantly practiced in this clinic with uniform success.

Neurolysis.—Neurolysis is directed toward the correction of physiological

TECHNIC OF NERVE SURGERY

interruptions—those cases in which the anatomical integrity of the nerve is preserved, but where function is inhibited by its constriction; or they may be due to one of, or a combination, of several factors: (1) *External compression* by scar tissue, bone callus, or any form of pressure. (2) *Thickening or infiltration of the nerve sheath* (Fig. 21 a-b). (3) *Interstitial fibrosis* (Fig. 21 c), due to the organization of an intraneural hemorrhage, to infection, or to that type of fibrosis which occasionally follows ischaemia.

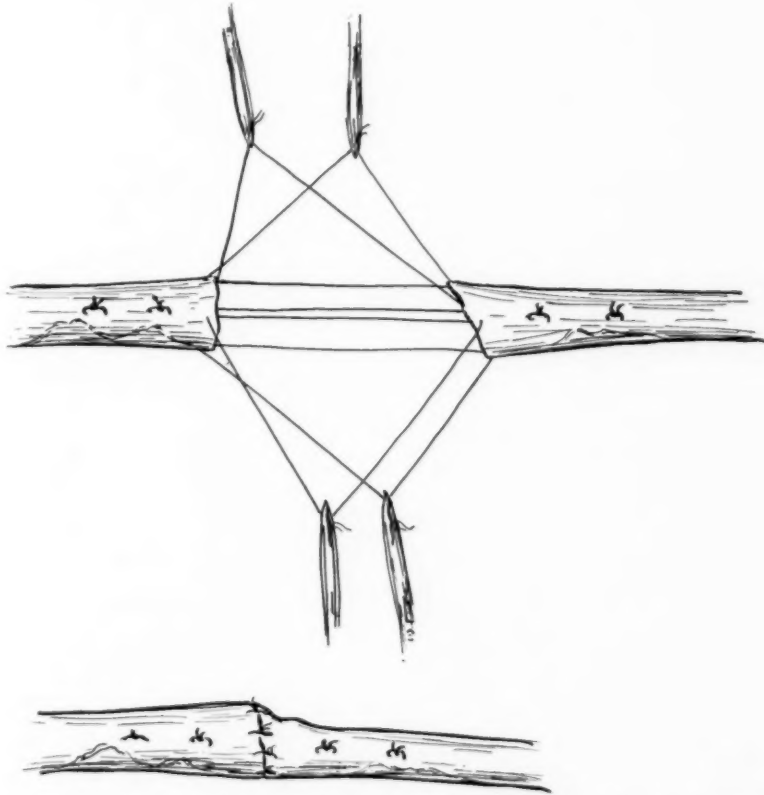


FIG. 13.—Diagonal section of distal segment where it is smaller than the proximal segment for the purpose of securing accurate sheath approximation.

Neurolysis consists in the removal of scar tissue or bone callus, which by virtue of its compressing effect produces a physiological inhibition of function. This procedure, as a rule, produces very gratifying functional results, and when completed should leave a nerve free of induration—the nerve at the point of operation should have the same consistency to palpation as the normal portions of the nerve. When, however, the nerve is freed of external scar and palpation of the trunk reveals induration, the operation of external neurolysis should not be considered adequate to correct the underlying pathology. The nerve trunk then must be invaded. Some operators on finding such a condition have advised resection of the scar infiltrated

region. We, however, before resorting to this more radical procedure, have found it expedient to open the nerve trunk for the purpose of determining the nature of the compression. Occasionally the constriction is found to be produced by a greatly *thickened nerve sheath*, the bundles retaining their continuity, but appearing smaller at the point of compression. In such cases the nerve sheath is allowed to remain open and the exposed bundles are protected by a fat transplant. Often a portion of the sheath may be resected and the defect filled with or covered by adjacent fat or a transplanted fat graft. When, however, upon opening the nerve trunk the bundles are found to be

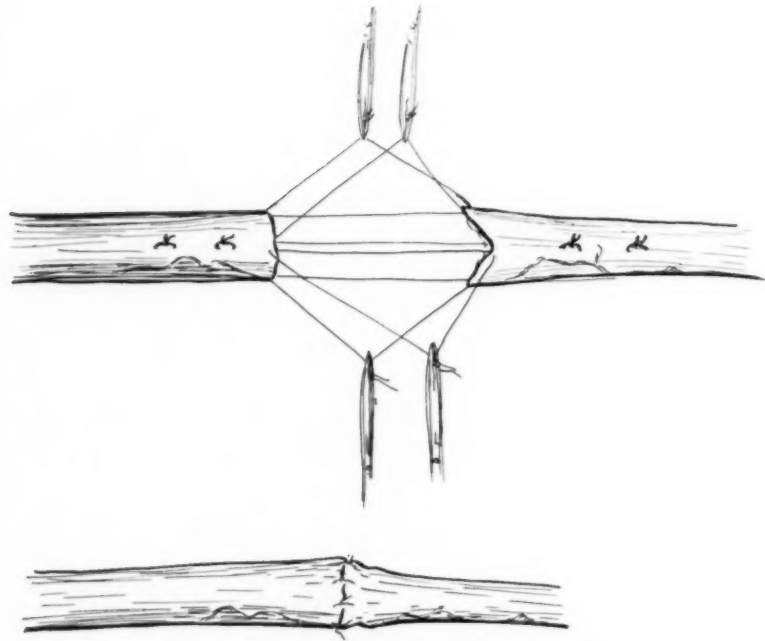


FIG. 14.—The "V" section of a small distal segment used for the same purpose as the diagonal section in Fig. 13.

incorporated in a mass of scar tissue, from which they cannot be separated, the surgeon is justified in completely resecting that portion of the nerve which is invaded by scar tissue. In certain cases, notably in *ischæmic paralyses*, the nerve bundles retain their individual continuity; are apparently normal in size, but are surrounded and adherent to each other by dense adhesions. In such instances it is advisable to separate these bundles by gently inserting between them the closed blades of a sharp-pointed iris scissors, and the careful spreading of the blades serves to break down the scar tissue and separate the bundles from the adhesions. The individual bundles are then carefully lifted on small glass hooks and separated to a point beyond the adhesions. When it is not possible to completely separate all of the bundles which are involved in the intraneural adhesions, the sheath should be freely separated and allowed

TECHNIC OF NERVE SURGERY

to remain open and the exposed bundles protected by surrounding fat. In the freeing of individual bundles, it is essential to remember that many nerves contain an internal plexus, and these bundles will frequently be found to anastomose one with the other in a plexiform arrangement; therefore, greatest care should be used to prevent their injury. It is needless to say, that with the completion of such a bundle dissection (which is done under a fine screen of saline solution) all oozing should be entirely controlled and all

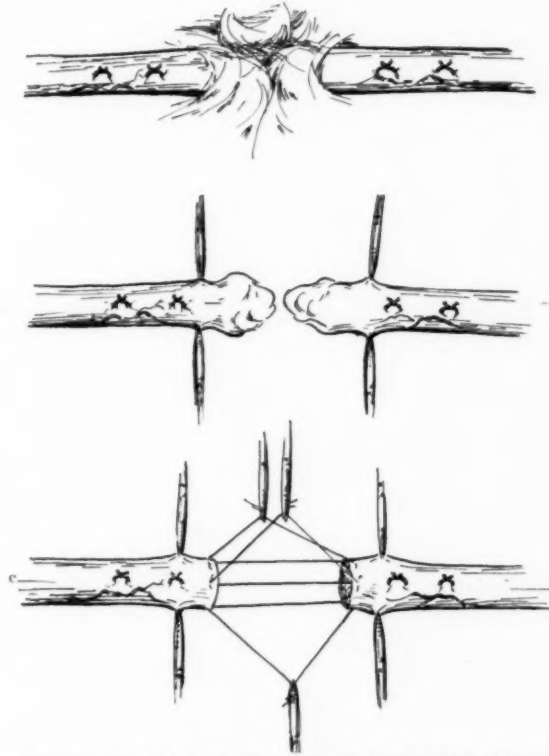


FIG. 15a.—Technic of end-to-end suture, showing the placing of identification sutures before a nerve is removed from scar tissue.

FIG. 15b.—Exposed nerve before resection of neuroma and scar from its ends.

FIG. 15c.—Nerve resected, identification forceps applied and three quadrant sutures placed.

blood-clots carefully washed away before closure is started—carelessness in this respect would probably be inviting the reformation of a certain amount of avoidable scar tissue. [NOTE.—On one occasion we thought it advisable to explore the popliteal vessels in a case of ischæmic palsy, which presented a complete sciatic paralysis below the knee of eighteen months' duration. This paralysis resulted from the application of a tourniquet used to produce hyperæmia in the treatment of a specific arthritis of the knee-joint—the tourniquet had been allowed to remain in place for eight hours. There was no pulsation in the vessels of the lower extremity. At operation the vessels were exposed

in the popliteal space and followed up through the adductor canal, beyond the point where the constriction had been applied; while there was found to be no obliteration of the vessels, some scar tissue was evident. The sciatic nerve which had been exposed felt rather hard: the nerve sheath was opened, and extensive perifunicular adhesions were found. The individual funiculi were freed from these adhesions for about twelve inches down the nerve and the sheath was left open. After six weeks there was a return of voluntary

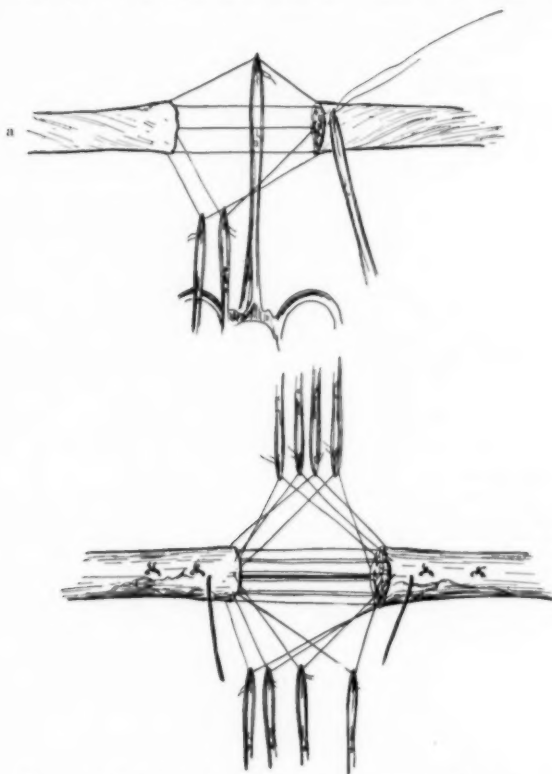


FIG. 16a.—Rotation of the nerve for the purpose of placing the posterior quadrant suture.

FIG. 16b.—Intermediate sutures placed and all sheath sutures held in position to prevent rotation in placing a tension suture.

action in the gastrocnemius; at the end of three months definite voluntary contractions were observed in the tibialis anticus, the extensors of the toes and peronei. The stocking type of anæsthesia which had extended almost to the knee was reduced from a total anæsthesia, including vibratory and pressure sense, to a tactile anæsthesia extending up the ankle. Subsequent communications regarding this patient indicate that there has been a complete return of sensation, and that all the muscles now respond to faradism and show voluntary motor power, except possibly some of the intrinsic muscles of the foot. This is a suggestion to be borne in mind in the treatment of palsies of ischæmic origin.]

TECHNIC OF NERVE SURGERY

The Influence of Technic on Final Functional Results.—While in all types of surgery the importance of specific technic is becoming more and more appreciated, there are few branches in which it is as important in regard to final functional results as in the surgery of peripheral nerves. Scar tissue, which is associated to a greater or lesser extent with all surgical interventions, is particularly important in reference to nerve surgery, and is often

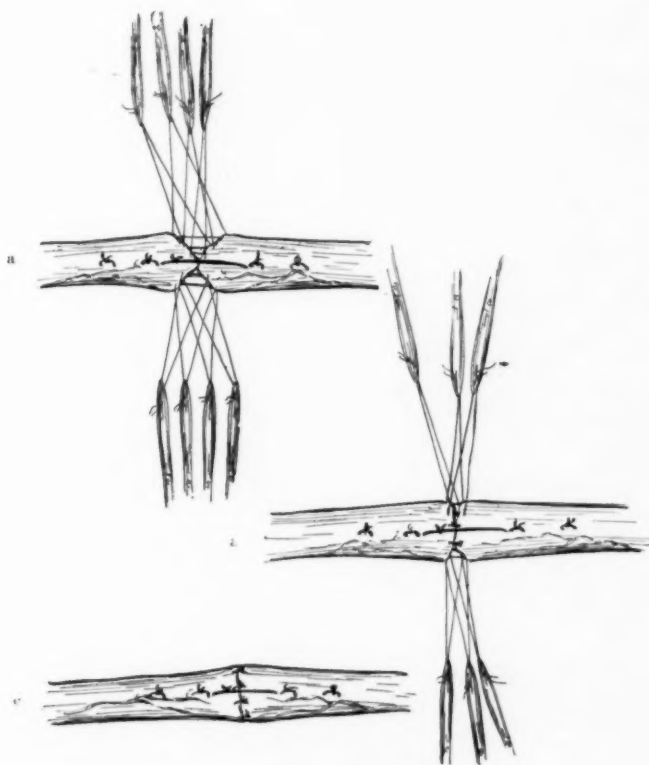


FIG. 17a.—Approximation by tying suture.

FIG. 17b.—Order in which sheath sutures are tied after nerve is approximated by the tension suture.

FIG. 17c.—End-to-end suture completed.

productive of a definite inhibitory influence on the functional return of motion and sensation. It is essential that the formation of scar tissue be eliminated to the greatest possible extent by the more refined methods of general surgical technic. In this particular, attention should be directed to hæmostasis and the removal of blood-clots, the avoidance of tissue trauma, by making clean, sharp dissections, and avoiding as much as possible the crushing effect of hæmostatic forceps, the avoidance of wound infection by the use of a careful instrumental technic, and by proper protection from skin contamination; it is also important that all tissues which are not receiving imme-

diate attention be protected and prevented from drying by the use of cotton pads which are kept saturated with warm saline solution.

The most important feature in nerve surgery, in so far as an ultimate physiological restoration of function is concerned, is the prevention of rotation or torsion of the nerve trunk in suture. At the present time we have no means at our disposal which will, to any degree of certainty, prevent a physiological misdirection of fibres, and in practically every instance of suture in

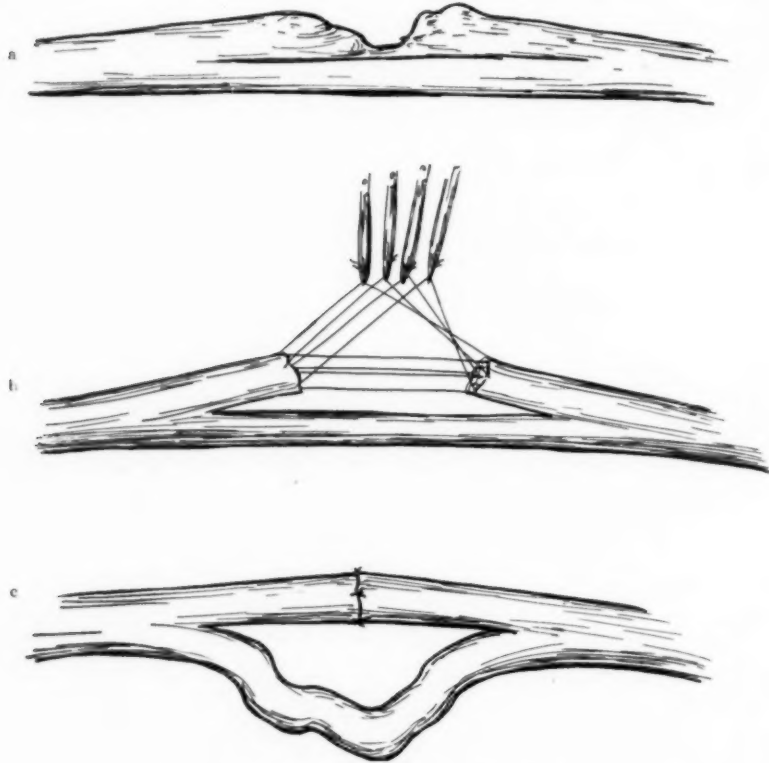


FIG. 18a.—Partial lesion of a nerve trunk.
 FIG. 18b.—Isolation of the interrupted portion from the physiological normal portion.
 FIG. 18c.—Approximation in partial suture such as a partial division of the sciatic nerve, showing the relaxed undivided portion of the nerve.

mixed moto-sensory nerves there is certain to be a number of fibres lost by being misdirected down physiologically differentiated channels; and until we have means of determining which bundles within a nerve trunk conduct sensory fibres and which conduct motor fibres, and are able to properly approximate those which subserve like functions, we will be unable to expect anything like perfect functional restoration following nerve suture. The fact that musculospiral sutures probably give the best functional result is accounted for by the fact that the musculospiral nerve contains so few sensory fibres that the chances of misdirection are diminished. The methods suggested in this

TECHNIC OF NERVE SURGERY

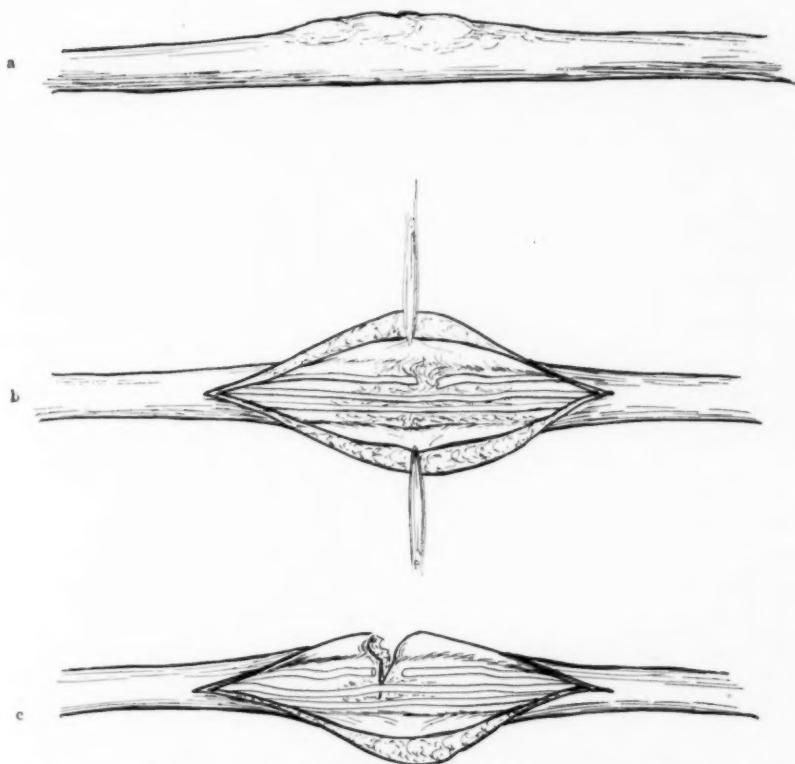


FIG. 19a.—A partial lesion of a nerve trunk, where gross anatomical isolation of the functional portion of a nerve cannot be made as in Fig. 18.

FIG. 19b.—Opening of the nerve sheath showing involvement bundle.

FIG. 19c.—A "V" shaped incision of sheath by which approximation of the bundle is made possible.

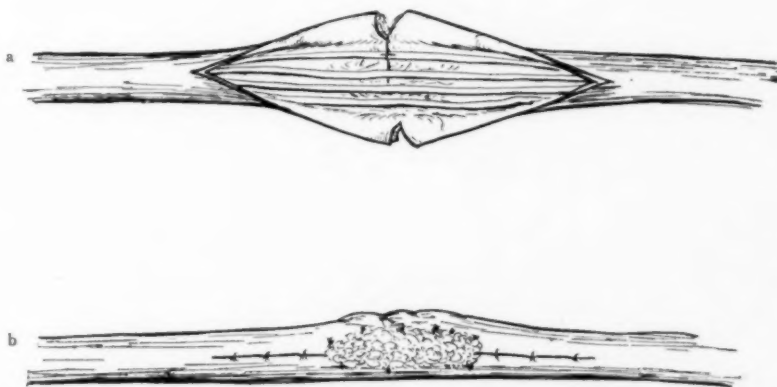


FIG. 20a.—The approximation of the divided bundle accomplished by relieving tension in the approximation of the resected sheath.

FIG. 20b.—The thickened sheath is not entirely closed for fear of strangulation—the defect repaired by a fat transplant.

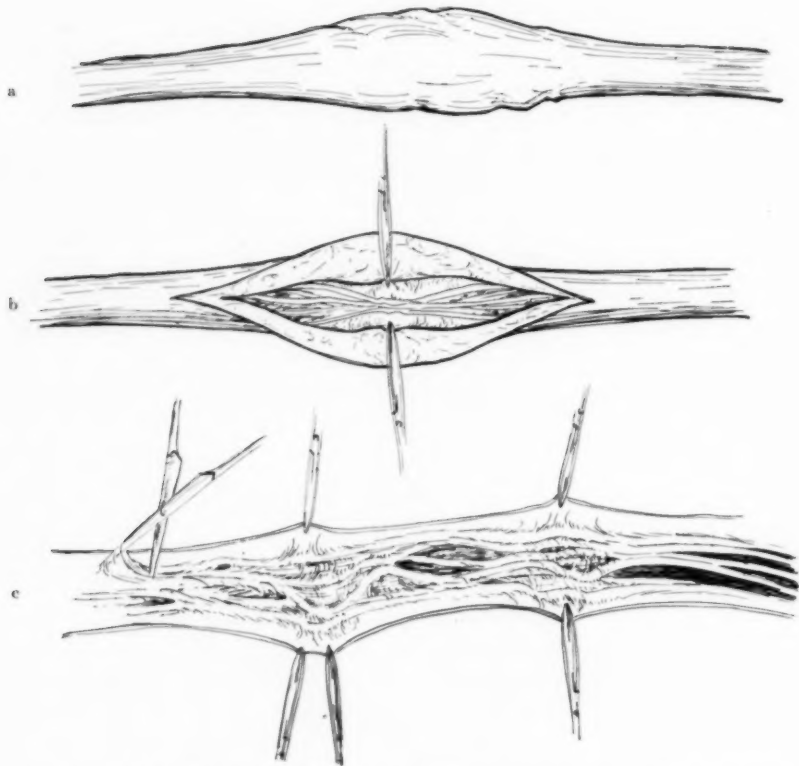


FIG. 21a.—Physiological interruption of a nerve—nerves with this appearance are occasionally considered as having an "internal neuroma."

FIG. 21b.—Showing the enlargement to be due to a greatly thickened nerve sheath, producing compression or strangulation.

FIG. 21c.—Perifunicular adhesions following the prolonged use of a tourniquet. The method of separation of adhesions, as in Figs. 21a and b. The sheath is left open to prevent future strangulation, and the exposed funiculi are protected by adjacent fatty tissues when present, or fat transplantation.

paper for the prevention of torsion have given fairly satisfactory results, but now and again we find cases in which in spite of these precautions taken to prevent torsion, it has evidently occurred, and there has been a diminished functional return in certain muscles. In some cases a return of function has been so perfect in most of the muscles that it requires a careful examination of individual muscle function to determine motor imperfections, and no doubt much of the resulting disability will be expressed only in a diminished ability to perform certain skilled movements, and there is a possibility that even these minor motor defects may in time be corrected in many individuals by reëducation and substitution movements.

THE SURGERY OF INFANTILE PARALYSIS*

BY J. TORRANCE RUGH, M.D.

OF PHILADELPHIA

It is an indisputable fact that, with the exception of the modern ill-fitting shoes, no other factor causes so large and so varied a number of deformities as infantile paralysis. This has not always been so, but with the frequently recurring epidemics in the past twenty years, the number of cases which come under the care of the orthopædic surgeon has increased tremendously. It is only when one considers that, in addition to the vast number which have been left with some form of paralysis, an equal or even greater number have recovered without any stigma of the disease, that one fully realizes the ravages and severity of this condition.

The surgical problems of the various stages of infantile paralysis have always proved of the greatest interest to the orthopædic and general surgeons. However, the very great increase in the number of cases following the widespread epidemic of 1916 has not only called forth tremendous surgical efforts from the orthopædic surgeons during the past two years, but has also proved an active stimulus to the creative genius of the surgeon, along mechanical lines, to more effectively deal with the problems that are constantly being presented. The time is not long since the surgery of flaccid paralysis was limited to a very small number of procedures. The treatment of this condition consisted entirely in the application of some form of brace, of massage, manipulation and more frequently of incantations until the introduction of subcutaneous tenotomy by Stromeyer, of Hanover, Germany, in 1831. This simple operation was the first great surgical procedure for the easy correction of many of the malformations associated with paralysis and formed an epoch in the surgery of deformities. It was introduced into America in 1837 by Dr. Wm. Detmold, and its use rapidly became general. The *Association Medical Journal*, London, June, 1855, says, "Never was any great operation involving a vital principal of surgery, spread in less time over the globe and with less resistance than tenotomy." No further advances were made in the surgery of this condition until in 1878, when arthrodesis for the stabilization of certain joints was performed and advocated by Albert of Vienna. The next epochal advance in the surgery of these deformities was brought out by Nicoladoni, who, in 1881, first transplanted one of the peroneal tendons into the tendo Achillis in a case of calcaneus, and this was the beginning of the development of that branch of work which has held the attention of orthopædic surgeons to the present day. In these earlier cases transplantation was always performed by inserting tendon into tendon, and the results of the work

* Annual Oration on Surgery, delivered before the Philadelphia Academy of Surgery, March 7, 1921.

in a large percentage of the cases proved disappointing because of the failure of the attachment to become permanent.

The next forward step was the work of Glück, who in 1892 first used silkworm gut sutures to bridge the gap in tendons. These were promptly substituted by strands of silk, and in 1896 Kummel, in the examination of a case several years after operation, "found that the strands of silk had become incorporated in and had changed into fibrous tissues." Willard in 1891, in a paper before the American Orthopædic Association, reported the use of tenotomies and resection of joints for the correction of paralytic deformities. In 1897, Goldthwait first reported the direct transplantation of muscles in the treatment of paralytic deformities, and about the same time Fritz Lange employed long silk cords for the transmission of power from a live muscle to a paralyzed part. Thus it will be seen that up to the beginning of the present century the correction of paralytic deformities by modern surgical methods was extremely elementary, and yet the field for the work was full of promise and the prospects afforded a tremendous stimulus to the creative efforts of the mechanical surgeon.

The surgery of paralysis of this era has now become obsolete. The insertion of tendon into tendon has been found entirely insufficient because of the stretching of the parts. The use of silk ligaments for the stabilization of a joint or the maintenance of a part in a given position or for the preservation of the continuity of a tendon for the transmission of muscle power, which at first offered such promising results and appeared to be the method which would afford the greatest relief and benefit in the treatment of these conditions, proved totally unreliable after trial. A silk insert will remain in place almost indefinitely and will act as a check to support a certain strain, but under continued tension and use it will become separated from the surrounding scar tissue and will gradually be extruded by a process of non-infectious supuration. It has not been my experience that a foreign substance such as silk will become a part of the tissue which surrounds it, even after a period of years, and almost all orthopædic surgeons have found that active use or strain upon such an insert will be followed by the loss of the insert through a process as above mentioned.

The active surgery of infantile paralysis is usually classed under the headings of corrective and reconstructive. The first includes those operations done during the stage of recovery from the attack of the disease and before the resultant or permanent paralysis has become established. The second includes the operative work after all possible recovery has obtained and the need is present for the building up and restoration of as much essential function as possible. I have always felt that there should be three divisions for this, the first to include corrective measures for those cases of deformity which occur during the first one or two years. In this period, tendon transference, tenodesis, arthrodesis, and such types of operation should not be done, as regeneration of nerve cells and partially paralyzed muscles has not yet been completed, and they may greatly interfere with the natural processes of recovery.

THE SURGERY OF INFANTILE PARALYSIS

The most useful procedure at this time is tenotomy, either partial or complete, and it is always to be supplemented with efficient mechanical restraint or support, developmental and corrective gymnastics, physio-therapy and training in the proper use of parts. Occasionally an osteotomy may be indicated, as in those cases with weakness or loss of the internal hamstrings and active function in the external which results in a knock-knee with a tendency to an external rotation or partial luxation of the tibia at the knee as well as a strain upon the foot and ankle structures which may result in deformity. It is almost impossible to hold such a leg by a brace, and yet it is essential to the proper functions of the foot that the leg be maintained straight. No destructive operation should be considered at this time. (By destructive operation is meant one which sacrifices certain functions in order that the most essential function of the part shall be conserved, such as arthrodesis, tenodesis, resection of bone, etc.) Thus it will be seen that during the first two years of the disease, surgery must be of the most elementary type, and much greater reliance must be placed upon mechanical and restorative means of treatment, such as physio-therapy, hydrotherapy, etc. The tendency on the part of many operators is to do too much and too radical surgery in the earlier years of the disease, and it not infrequently happens that they thus destroy the chances of recovery in certain parts that would be of the greatest benefit to the patient. Prevention of deformity and correction by the simplest procedures are the keynote of the surgery during the stage of active regeneration and recovery from the attack.

After this period has elapsed and further regeneration has begun to be more slow and retarded, we may consider the second type of surgery, viz., constructive. The aim of this is to preserve as many of the functions in the part as possible rather than the establishment of one or two essentials. The total loss of power in or the weakness of one muscle or of a group allows the onset of unbalanced and faulty positions which, if permitted to persist, will result in deformity. If, now, a complete loss of power and degeneration of the muscles can be demonstrated, surgery is to be considered "to utilize what is ill-directed voluntary movement and to restore the balance of power so far as possible in the affected part" (Jones & Tubby).

There are certain principles concerned in the adaptation of surgical methods in these cases. In the first place, there is the mechanical principle of the condition itself. This must be carefully studied both as to the function of the part and as to the proper and best means of preserving it. In many instances, mechanical measures will suffice to maintain proper function, and in those cases in which there is a certain amount of power remaining, mechanical correction will relieve these parts of strain and will permit of a fairly rapid return of power and function in them. When, however, the balance is disturbed by overaction on the part of certain muscles or groups of muscles, surgical measures must be used to again restore it.

In the next place, the mechanics and the mechanical relations of related parts must be considered because of their effect upon the function of the part

in question. This is well illustrated in a case where the foot is in a position of adduction and the knee in valgum. The one tends very greatly to exaggerate the other and neither one can be corrected and maintained without the complete correction of the other.

In the third place, one must consider the mechanics of the surgical procedure to be employed in the correction of a given case. These must be as simple as possible and must be accurately adapted to the needs of the individual case. It is well recognized that in many of these conditions there are two types of operative procedures in the muscle and tendon structures, viz., those which concern structures having analogous functions and those having opposing functions. It is also conceded that those of the first group more readily adapt themselves both surgically and functionally to the betterment of the condition than those of the second group. When tendon transplantation first began to be generally considered in these cases, the question arose as to whether there would be difficulty in reëducating the part or the muscle in its changed position. This is still a debatable proposition in that it concerns direct and indirect cerebration. There is no doubt that in the great majority of individuals, the impulse to actuate a certain movement is inseparably connected with the movement of the part and not with the action of the muscle which moves the part. The impulse, therefore, expresses itself to the mind in terms of motion of the part and not in the contraction of the muscle itself. This is so because in most persons movement is automatic and is not concerned with the direct function of a muscle or group of muscles. One fully realizes this in the attempts at muscle training for the purpose of corrective work in certain deformities. The very small proportion of individuals who possess voluntary control over muscle action is startling. Great patience and labor are frequently necessary to the proper development of muscle intelligence on the part of patients and some do not possess the ability to develop it at all. The attempt, therefore, to convert a flexor into an extensor or vice versa, or an adductor into an abductor or the contrary, will meet with failure in a large percentage of cases because of the lack of muscle intelligence or muscle sense in so many patients. Again, there must be an actual reversal of the thought image in the mind of the patient and the impulse must be transformed into its opposite until it can become automatic with the individual. Fortunately, however, for the purpose of the work in many cases of infantile paralysis, this becomes extremely easy and the reversal of the impulse of action entirely unnecessary, in fact impossible, because the opposing impulse cannot be delivered on account of the loss of its motor centers, and all that is necessary is that the same automatic contraction of the active muscles shall continue in order that the part may be moved in the proper direction.

By far the best results in the transplantation of live tendons are obtained where a tendon having a similar function to the paralyzed one can be substituted for it. However, there are certain factors which must be taken into consideration in these procedures. In the first place, it is useless to transplant a weak tendon where a strong one is needed. In the earlier days of this work,

THE SURGERY OF INFANTILE PARALYSIS

probably more failures resulted from disregard of this principle than from any other factor. For instance, the posterior tibial tendon or the peroneal tendons cannot possibly replace the tendo Achillis and the tibialis anticus cannot possibly perform all the functions of the dorsal flexors of the foot and toes. But in either case they may aid tremendously in the reestablishment of the preservation of functions when additional measures for support and stabilization are employed. It has been very succinctly stated clinically that a pale muscle should not be transplanted at all, a pink one may be used but a red one is best (Soutter). Again, the function of the transplanted tendon should approximate as nearly as possible that of the paralyzed one and its pull must be made in the same direction. For instance, where an anterior tibial is used to aid in dorsi-flexion of the foot, it must be attached as far down on the dorsum of the foot as possible so that it may have and may exercise a greater leverage upon the part as nearly equal to the common extensors as possible. This likewise holds true in all other cases of substitution and is an extremely important principle of operation. Again, it is now quite well established that if the sheath of the tendon can be transplanted with the tendon or, failing in this, if the transplanted tendon can be conducted through the sheath of the tendon whose function it is intended to replace, there will be much less impairment in the excursion of the tendon and hence better function in the part to be actuated. Again, the attachment of a tendon should be made either directly to or into a bone or subperiosteally. There has been a large percentage of failures from the attempted union of tendon with tendon because of the very slow repair in this tissue and because of the type of union which occurs. The other method of attachment gives much greater assurance of success and should be utilized wherever possible. Union between the end of the tendon and the bone or periosteum can be made much more certain if, on the removal of the tendon from its original attachment, a small layer of bone is included and this is placed in contact with bone or periosteum. By this means bony union is obtained instead of the fibrous union which occurs otherwise. The operation of tendon transplantation, both direct and indirect, has proven a very great advance in the surgery of infantile paralysis, but it is gradually reaching its level of efficiency and success, and it is safe to say that the next ten years will see a much smaller number of cases operated upon by this method than by some of the others. Conservatism in this field is becoming more and more pronounced and the limitations of tendon transplantation are being much more accurately defined. It is now generally conceded that it is practically useless to do it prior to ten or twelve years of age. This is true by reason of the fact that prior to this age it is almost impossible to secure the coöperation of the patient for the development of the special functions in the transplanted tendons. Of course, this does not obtain in that class where skilled aids can be employed over a long period of time and where the patient can be given a special training that is so essential to success, but unfortunately so many of these cases cannot afford such special training and care, and in such patients the procedure must

be left until a later period. The social status, therefore, of the patient becomes of the utmost importance in determining what shall be done for the correction or the elimination of a deformity.

For the resultant paralysis (that which persists after five or six years have passed), when the probability of any further regeneration of muscle and nerve tissue or of nerve cells is entirely gone, another type of surgery can be considered, and its most useful field is in the correction of many of these permanently crippled and deformed. This is really the third type of surgery which can be well termed "reconstructive surgery," because it has for its purpose the rebuilding of a part or of parts for the purpose of establishing one or two essential functions in the part even though at the expense of all other functions. Under this heading are included those operations generally of a destructive character, such as arthrodesis, resection, cuneiform osteotomy, tenodesis, bone transplantation and the construction of ligaments out of tendons, fascia and other structures. It is not my purpose to detail all of the operative procedures under the constructive and reconstructive headings which have proven themselves of value in these paralytic cases, as the time required would be entirely too long. A few, however, stand out rather prominently in their worth and these we will mention.

Before proceeding to the consideration of these, however, it is pertinent to speak of a procedure from which the greatest possible benefit was at first hoped, viz., that of nerve transplantation and nerve grafting. On theoretical grounds these operations should have proven the solution of the surgery of infantile paralysis, but unfortunately human tissues and structures will not always follow functionally and anatomically the surgeon's theories. The direct transplantation of a live nerve into the distal end of a severed paralyzed one has always resulted in failure; likewise, the anastomosis of a live with a paralyzed nerve has availed nothing. The direct implantation of a live nerve into a paralyzed muscle has resulted in a slight growth of the neuraxes into the muscle tissue, but there has been no regeneration or functioning of the muscle tissue as a result. Live muscles have been carefully anastomosed over a large surface with paralyzed ones in the hope that neurotization of these would occur but without results. It has often occurred to the writer that if it were possible to determine very early in the onset of the paralysis which muscles would be permanently paralyzed, a transplantation of a live nerve into those muscles before degeneration had taken place or perhaps into the nerve trunks before they underwent degeneration, might preserve the functions in these parts. However, on account of the nature of the infection in the spinal cord and of the involvement of the motor cells, such a determination is absolutely impossible.

Experiments on animals have been recorded wherein a motor nerve has been resected and a portion of another motor nerve has been inserted into the distal part; after six weeks or so, a return of power was noticed in the muscles supplied by the resected nerve, which gradually increased and in due time approximated the normal, and it was concluded that there had been an

establishment of function through the transplanted nerve. Careful dissection of the part, however, showed that the original nerve which had been resected had reestablished its connections with the distal portion and that the motor function took place through this and not through the transplanted nerve (Steindler). This field of surgery, however, is so intensely interesting and theoretically so promising in results that investigations will be continued with these structures until it shall have been proven either an assured possibility or a total failure.

About 1910, Putti of Bologna, Italy, acting upon a suggestion of his predecessor, Codivilla, began the manufacture of ligaments out of the tendons of paralyzed muscles for the purpose of stabilizing joints and maintaining a part in a given position. His experience with the silk ligaments and other foreign substances had been similar to that of other operators, and it was felt that if normal tissues or structures could be utilized to maintain a part in balance, the danger of loss of the restraining ligament would be obviated. Codivilla had first buried the tendon under the periosteum in order to fix the proximal end for purposes of holding a part, and this plan has been amplified by Gallie of Toronto and has been extensively followed by many orthopaedic surgeons. Putti, however, separated the tendon from the muscle and passed it through a hole drilled in the bone and then back between the periosteum and the bone and securely fastened it to itself and the periosteum. This plan of operation has given better results in my hands than any other procedure, though many operators have reported failures in its use. There are several factors essential to successful tenodesis after both methods. In the first place, it has been stated by many men that the tendons of these paralyzed muscles stretch under the effects of strain. My own opinion is that it is not the tendon which stretches but rather the old degenerated muscle to which the tendon is attached. If the tendon has been detached from this structure and fixed into a bone and recurrence of the deformity has occurred, the recurrence has been due not to the stretching of the tendon but to a slipping of its attachment, which is fibrous in all cases and which proved in the earlier days of transplantation entirely unreliable. Then too, if, in the fixation of the tendon, complete removal of all peritendinous tissue or sheath has not been accomplished, this tissue will unite with the bone and periosteum, and under strain the tendon will slip through and allow recurrence of the deformity. Histologically, tendons are but very slightly elastic and the amount of stretching which takes place under tension is extremely limited. Another factor in the recurrence of deformity after this operation is that between the two attachments of the tendon now made into a ligament, there are usually several joints and the flexion or bending of these joints permits of movement of the part without any lengthening of the tendon structure. This is well seen in the front or on the side of the foot where a ligament has been formed from a neighboring tendon. There is still much to be desired from tenodesis in these cases, but there is no doubt that this method of restraint offers better and more lasting results than any other yet devised. Where the pull on this liga-

ment is a direct one as from the posterior part of the tibia to the os calcis when the tendo Achillis or a portion of it is fixed into the tibia, the part will stand quite a degree of strain after firm union has been secured.

Peckham, of Providence, has utilized for the same purpose a strip of fascia dissected from the side of the leg and passed downward through a tunnel under the skin and attached to the foot below. This forms a dense scar of connective tissue which aids in maintaining a part in a given position. However, the great tendency of scar tissue to stretch, limits the amount of strain which such a structure will carry. A strip of fascia from the side of the thigh or other part may also be used as a free transplant to form a ligament, though the free flap transplant is more liable to become infected and discharged than is one with a pedicle and hence is not so safe a procedure.

Another operation which has proven of very great value in stabilizing a foot in which there is very free lateral motion, especially between the astragalus and os calcis, is one originated by the late Dr. G. G. Davis and is known as *sub-astragalar arthrodesis*. The real purpose of the fixation of the articulation between the astragalus and os calcis is the fixation of the heel. It is well recognized that if the heel of the foot can be maintained in a proper position, the rest of the foot will likewise remain balanced. The destruction of the joint is accomplished through a lateral incision below each malleolus, the tendons on each side are displaced, and with an osteotome or chisel the entire articulation is thoroughly destroyed, the pieces of cartilage and bone being left in situ. The lateral incisions are closed and the foot is held in plaster of Paris for two or three months until firm union between these bones obtains. In some cases, it is well to combine with this a destruction of the astragalo-scaphoid joint as well. These operations are extremely simple, free from danger and have proven most satisfactory in cases of lateral instability of the foot. Tendon transplantations and tenodesis may be combined with this operation.

Where the ankle itself is flail, and there is no prospect of any further regeneration of muscle, many operators have performed an arthrodesis of the tibio-astragalar articulation to secure stabilization of the foot. When this result obtains, the walk becomes extremely awkward, though, of course, in standing the position is excellent. However, the ultimate results of a large number of cases over a long period of years have practically determined its abandonment by most operators. Greater reliance is now placed upon the use of the Whitman or the Davis operation combined with tenodeses and ligament construction.

Another form of deformity which has proven extremely troublesome is that of calcaneus due to paralysis of the gastrocnemius and soleus muscles. Whitman, of New York, many years ago originated a plan of treatment which has proven most satisfactory in these cases. The mechanical principle involved is that of placing the weight of the body nearer the center of the foot, and he accomplished this by removing the astragalus and then dislocating the foot backward after having made a new seat for the malleoli as far forward as possi-

THE SURGERY OF INFANTILE PARALYSIS

ble. Valgus or varus may be present in these cases and either of these malpositions must be considered in the after placement of the foot. Whitman also transplants certain of the posterior muscles into the os calcis in order to assist in maintaining the foot in equinus. When plaster of Paris is applied, the foot is placed in the position of equinus and recovery takes place in this position, which not only eliminates the former deformity but also compensates for the shortening caused by the removal of the astragalus. In the severe cases of calcaneus, there is no other surgical procedure which will give as good results as astragaelectomy and as in all operative procedures in paralytic cases, the after treatment must be most carefully carried out to safeguard against relapse. In the milder cases of calcaneus, where there is a less degree of contraction of the plantar fascia and the os calcis is not tilted forward so far, Davis secured the same mechanical result as Whitman by performing what he called a *transverse horizontal section* and dislocating the foot backwards. This operation is accomplished through an incision on one or both sides of the foot, and then with an osteotome the body of the astragalus is cut through horizontally just below the malleoli and the incision is carried in the same plane forward through the tarsal bones; the periosteum is then freely separated from the tarsal bones below the incision in front and on each side, and the tissues on the posterior portion above the incision are dissected up sufficiently to allow the foot to be dislocated backwards a half inch or more. The skin incisions are closed, the foot is pushed backward as far as possible and is preferably held in plaster in the position of equinus for from eight to ten weeks. Tendon transplantation and tenodesis may be combined with this procedure. This method is extremely efficient in the milder cases and possesses a great advantage over astragaelectomy in that there is no shortening furthermore, the operation is not at all serious and is not mutilating.

At the knee-joint a flail condition in an adult is best controlled by an arthrodesis and the patella may be advantageously ankylosed to the femur and tibia at the same time to provide greater stability. Where there is weakness or paralysis of the quadriceps extensor muscle, much good may be accomplished by the transplantation of a live biceps, external hamstring or sartorius into the patella. Where this attachment holds, a brace at the knee can usually be dispensed with. For faulty lateral positions of the leg at the knee, an osteotomy gives the most satisfactory results.

A flail hip proves one of the most difficult conditions with which the surgeon has to contend. If there is ilio-psoas power, a brace can be applied which will enable the patient to walk, but if there is total paralysis, arthrodesis of the hip joint is the only procedure which will be of any benefit to the patient. In all of these cases where ankylosis is attempted, especially in the larger joints, the patient should be above ten years of age and better results are obtained in the older cases than in the younger ones. Firm fibrous ankylosis is preferable to flaccidity, and in some of the tarsal joints of the foot an arthrodesis may be done under ten years to advantage.

Another distressing condition in the paralytic cases is that of a scoliosis which develops with involvement of the spinal and abdominal muscles. One of the most difficult mechanical problems is the fitting of a support which will maintain the body of one of these paralytics in a straight position. The skin will not stand the pressure that is necessary for the support of the upper trunk and extremities. A plastic operation on the spine offers better results in the treatment of these cases of permanent paralysis than any other procedure. This operation may be that of a bone graft taken from the tibia or of a plastic character as advocated by Hibbs of New York and Forbes of Montreal. The spine is fixed at the point of greatest curvature, but before the operation is done an attempt should always be made to secure as much correction of the curve as possible. External fixation by plaster, jacket or brace is maintained for one or two years until bony ankylosis is complete.

The arm paralyses offer greater difficulties to surgical improvement than do those of the lower extremity. The most difficult with which to deal and in which to secure functional benefits are those of the shoulder. Muscle transplantations about this part have been performed but the degree of improvement which has been obtained is not of the most encouraging character. The trapezius has been used to supplant the deltoid, as has also the pectoralis major, but the leverage of the arm at the shoulder-joint is so disadvantageous that the results from these operations are not brilliant. I have obtained better results in the deltoid form of paralysis by an arthrodesis of the joint with the humerus at an angle of about 60 degrees. This posture enables rather free use of the arm through the action of the scapular and other chest muscles, and the function may be improved at least 50 per cent. Where there is loss of the biceps with inability to flex the arm, Sir Robert Jones advocates the removal of a diamond-shaped flap of skin from the front of the elbow and the closure of the edges of this denuded area to obtain a permanently flexed position of the arm. Where there is good power in the wrist and hand this operation aids very much in certain functions of the arm. In paralysis of the flexors or extensors of the fingers the transplantation of the carpi radialis or ulnaris of either the flexor or extensor group may be utilized to very great advantage. Almost any of these specialized tendons lend themselves well to transplantation, and attachment of tendon to tendon may be made in these parts with advantage because of the greatly lessened strain upon the point of union as compared with that of the foot and leg where the element of body-weight proves of the greatest possible disadvantage.

While the surgery of infantile paralysis has been proven to be one of the most beneficial agents in correcting deformities and in reconstructing parts for the development and maintenance of function, there are two aids which may never be lost sight of in the quest for success. These two aids are proper and efficient mechanical support until sufficient power has developed to take care of the condition and development exercises and training to improve and increase the power which may remain in any of the muscle

THE SURGERY OF INFANTILE PARALYSIS

structures. Coördinate and coöperative efforts are absolutely essential to this work. Patience, perseverance and an unlimited fund of optimism are indispensable to the securing of the ultimate results in these cases. One may never relax his efforts for a moment until the final purposes of the work are assured, even though the efforts may require years for their accomplishment. When the surgeon can examine one of these deformed paralytics which is commonly considered hopeless by the physician and the friends, and can visualize the end results of treatment which may require a period of years for their accomplishment and can then carry out the plan of treatment to a successful termination, he experiences a sense of satisfaction in the improved or finished product of his labors which can come from no other source.

FRACTURE OF THE SKULL IN CHILDREN*

A STATISTICAL SURVEY OF 100 CASES

By JOHN J. MOORHEAD, M.D.

VISITING SURGEON, NEW YORK POST-GRADUATE AND HARLEM HOSPITALS

AND

WALTER WELLER, M.D.

CLINICAL ASST., NEW YORK POST-GRADUATE HOSPITAL
OF NEW YORK, N. Y.

THIS group of cases is from the surgical service of Harlem Hospital and comprises 100 consecutive cases treated by four visiting surgeons or their associates or assistants. No attempt has been made to segregate the cases in respect to age, manner of accident, clinical manifestations, treatment or end-result, the primary object being to ascertain the surgical end results with and without operation. In a few instances it has been possible to trace the end-results after leaving the hospital, but the data thus obtained are too limited to be recorded. The age limits in this group range from three months to sixteen years; average, six and one-half years.

By common consent, surgeons agree that children withstand head injury better than adults in respect to the immediate as well as the late results, and they are also in agreement respecting the probability of unfavorable complications arising during convalescence, especially such occurrences as pneumonia and the eruptive fevers. The incidence of meningitis is also supposed to appear with greater frequency among children, and this is often of the pneumococcus variety, or is the outcome of nasopharyngeal infection from potential foci represented by tonsils, adenoids, otitic or other more or less quiescent factors.

Natural resiliency of the skull in children is primarily responsible for the freedom from severe bursting or crushing effects, and in this respect skull injuries parallel chest injuries within the same age limits. Ossification of the skull is complete relatively early, but it changes in form and size until puberty, although the fontanelles close within the first or second year. Hence, after the seventeenth year, skull injuries from a clinical standpoint fall into the adult group in whom an average mortality of between 40 and 50 per cent. is recorded in basal cases by most observers. Spreading fractures from vault to base, or from base to vault, add to this mortality among adults, making it approximately 50 to 60 per cent. In looking up the statistics of skull injury in children, various writers state that in vault injuries the mortality is 10 to 20 per cent., in basal injuries 30 to 50 per cent., and in combined vault and base injuries

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FRACTURE OF THE SKULL IN CHILDREN

30 to 60 per cent. Our statistics show that in vault cases the mortality is 5 per cent., in basal cases 10 per cent., and in vault and basal combinations 11 per cent. Of this group of 100 cases, only five fatal cases sustained injury to the vault alone (5 per cent.), ten involved the base alone (10 per cent.), and eleven showed combined injury of vault and base (11 per cent.). In other words, in a total mortality of twenty-six cases (26 per cent.) the involvement of the base meant a mortality of 38.4 per cent. of the total. Stated in another way, involvement of the base in any form meant a mortality of 80.7 per cent. of the total mortality. In the twenty-six fatal cases herein quoted there were multiple injuries in nine cases. If these are excluded, the mortality in our group of skull injury *per se* is 17 per cent.; of these four had been operated upon. The combination of vault and basal fractures is very common in adults, about 80 per cent, radiating from vault to base and vice versa. In children this proportion is less for anatomical reasons and in our series aggregated 32 per cent. The vast majority of our cases were injured by falls or automobiles; many of the injured were subjected to severe violence, so that the causative factors are representative of what is usually encountered in a large hospital serving a congested district of the city.

Symptoms.—The cardinal signs of head injury in children resemble those found among adults, with the exception that manifest evidences of localization from meningeal hemorrhage are far less common because that form of injury appears relatively rare.

From a clinical standpoint there are four main types of skull injury, and these conform to the adult grouping.

Type I.—(a) Concussion + vault fracture. (b) Concussion + basal fracture. (c) Concussion + vault and base fracture.

These cases are more or less conscious on arrival at the hospital, a hæmatoma or definite fracture line is demonstrable in the vault group; hemorrhage from the orifices is apparent in the basal group or a late ecchymosis (conjunctival, pharyngeal or retromastoid) makes the diagnosis with or without corroboration by spinal tap, neurologic, eye, ear or X-ray findings. This is the commonest group and most cases recover unless intracerebral pressure is marked or meningitis occurs.

Type II.—Concussion + latent interval + focal symptoms (at first irritative and later paralytic) + definite or indefinite signs of vault and base fracture. This is an unusual group in children, and with or without operation the prognosis is bad.

In adults this clinical combination can occur without skull fracture; but in children, fracture is almost inevitable.

Type III.—Concussion + persisting coma + definite signs of vault or basal fracture (or both) with convulsions, spasticities, high temperature, rapid pulse, embarrassed respiration and exitus. This is a sequel of severe injury with brain laceration, and, from a surgical relief standpoint, little can be done or even expected.

Type IV.—Concussion + vault or base fracture (or both) + evidences of intracerebral pressure (due to bone, blood, fluid or foreign bodies). These are the cases on the borderline as they present some of the evidences pertaining to the three types already mentioned, particularly Types I and II. The differential diagnosis as between this type and meningitis is exceedingly difficult, and in alcoholic adults with the same symptom-complex, alcoholic serous meningitis often proves to be the correct diagnosis. X-ray, neurologic, ocular and spinal fluid examinations are most valuable in this group, and the decision as to operative interference is often thereby determined. Most of these cases die and those recovering often give demonstrable evidences of mental deficiency with or without peripheral or cranial nerve defects.

Differential Diagnosis.—As indicated, this is not particularly difficult except in Types I and IV, in which concussion and meningitis are respectively confusing. In this connection it is pertinent to say that concussion means *immediate temporary unconsciousness, usually associated with vomiting*. If the elements of *immediate onset with temporary duration* do not exist, then the condition is not true concussion.

Confusion as between head injury, with or without skull fracture, can be definitely determined in only three ways, namely, through inspection (as by incising a hæmatoma), by spinal tap or by X-ray examination. The differential diagnosis as between hæmatoma and depressed fracture is especially puzzling in children, much more so than in adults; in case of doubt, it is the part of wisdom to incise and actually see and feel. In scalp wounds also it is important to exclude fracture by actual vision or palpation before assuming that the skull is unbroken; this becomes imperative when direct or localized violence is the causative factor. X-ray interpretation in children is harder than in adults, because the suture lines are more puzzling, because the thickness of the bones varies, and notably because children often move when the plate is being made. In making a spinal tap an even admixture of blood and cerebrospinal fluid is pathognomonic of skull injury, but an uneven admixture is very doubtful. Blood-pressure and eye signs have not been found as valuable as in adults. Choked disk as a sign of intracerebral pressure is a much overrated symptom, and Martin Cohen says that he never observed it in a series of adult cases carefully followed at Harlem Hospital.

Prognostic Elements.—Types I and II are the recoverable group; Type III is practically always fatal; Type IV often ends in recovery if meningitis is of a non-virulent grade. The vast majority of fatal cases die within the first forty-eight hours, and cases ending fatally after that period usually die of meningitis, pneumonia, an eruptive fever, or other more or less related intervening causes.

Spasticities or general convulsions are bad signs. High temperature with irritability usually means laceration of brain substance, with a correspondingly bad outlook. Localized depressed fractures of the vault

FRACTURE OF THE SKULL IN CHILDREN

give the best prognosis in the operable group. Spontaneous decompression by copious nasal or aural hemorrhage means a better prognosis than in a basal fracture with little or no external bleeding. The onset of pneumonia, an eruptive fever or other complication within the first week may prove serious; after that period, meningitis excepted, such a complication is often well tolerated. Latent or active otitis media in basal fractures may be the starting-point toward a fatality in an otherwise recoverable case. Of the eruptive fevers, scarlet and measles are the most common, the most dangerous. A patient with early onset of stertorous breathing rarely recovers; Cheyne-Stokes respiration means early exitus. Prolonged coma of itself is not a bad omen; if associated with fever, paralysis, meningitis, a fatality may be expected. Acidosis is a rare occurrence in head injuries unless vomiting or abdominal injury is added.

Treatment.—The routine management is important, and any suspected case should be kept absolutely quiet until all objective signs subside. In a conscious patient, bromides are given by mouth or rectally for appropriate reasons. Urotropin is administered every four hours for several days. Ten per cent. argyrol or $3\frac{1}{2}$ per cent. watery solution of iodine is instilled into the nose and ears twice daily. Catheterization is employed every eight hours when needed. Bowels are moved by enemata daily. If diagnosis is in doubt, the entire scalp is shaved, careful bimanual palpation is made for hæmatomatous or other thickenings, and, if necessary, such areas are incised. A spinal tap is performed to exclude basal fracture when necessary. For the first twelve hours suspected cases have temperature, pulse and respiration recorded every one-half hour. Blood-pressure readings and eye findings, as stated, are less valuable than in adults, but these diagnostic aids should not be neglected in doubtful cases.

Operative Treatment.—The one cardinal indication for operation is *pressure*, and this can arise only from bone, blood, serum, pus or foreign bodies. In children, as in adults, there is a zone which is involved in about 80 per cent. of cases. That is what I denote as the "two-inch zone," and it corresponds to an area two inches in front of and two inches behind an arbitrary line circling the vault and base from one ear orifice to the other. This takes in the fronto-parietal and the temporal bone areas; it includes the motor-cortical areas; also the most frequently involved areas of the under part of the brain and the basal fossæ. If in addition we bear in mind that nearly all fractures involve the vault and base, the probable site of damage falls well into a rule of averages and hence the internal extent of the lesion rather than the external site is an important rule as to operative indications. The fracture may mean nothing; the pressure everything.

Operation may be demanded as an *immediate*, *intermediate* or *late* procedure, depending upon the intracerebral lesion rather than upon the

extracerebral site of injury. The presence of shock or associated injuries may, of course, modify our judgment as to the time or extent of operation, and indeed, either or both of these factors may make operation too great a hazard even in the presence of a grossly compounded vault fracture.

Immediate operation (within a few hours) is indicated for:

(a) Compound depressed fractures of the vault in which there is manifest involvement of the inner table, making pressure by bone probable. Here operation is undertaken for the double purpose of preventing infection and relieving pressure. In many of this group the inner table will be found much more damaged than the outer, and in many, spiculæ of bone will penetrate the dura and enter the brain substance. These bone fragments are often hard to dislodge, but Cushing's procedure of introducing saline solution through a soft rubber catheter will bring them to the surface and at the same time wash out débris along the wound tract. This form of mechanical débridement is as helpful in civil wounds as in war wounds.

(b) Cortical hemorrhage, usually from middle meningeal vessels. Here the approach is by the subtemporal decompression method or by bone flap.

Intermediate operation (after several hours) is indicated for:

(a) Cortical hemorrhage in which the extent of invasion is progressive or stationary.

(b) Generalized intracerebral pressure in which spinal taps fail to relieve symptoms.

(c) Foreign bodies previously well localized by clinical and X-ray examination. Many of these are best removed by operating under the guidance of the fluoroscope.

Late operation (after several days) is indicated for:

(a) Purulent (abscess) or serous (cyst) collections.

(b) Sequelæ of rare type, such as epilepsy or pressure or irritative manifestations.

(c) Deformations, such as cranial defects with or without hernia cerebri.

It will be noted that operation is not advised as a routine, for it is our experience that general intracerebral pressure due to effused blood is best relieved by spinal tap. When, however, the bony envelope is distorted by depressed fracture, and when the hemorrhage is in the main focal or cortical, operation is the best procedure. In unconscious patients little, if any, anæsthesia may be needed until the pressure is released, but it has been our experience to have a child, previously unconscious in the early stages of the operation, rouse up when bone has been elevated or clot removed. In our 100 quoted cases, twelve were operated upon, nine for vault and three for combined base and vault fracture. In the former group, one died (11 per cent.); in the latter, two (66.6 per cent.). Of twelve operated cases, four died (33.3 per cent.).

It is often unnecessary to remove more than a small segment of bone,

FRACTURE OF THE SKULL IN CHILDREN

but much care is necessary to definitely ascertain by finger palpation that no portion of the inner table is left within.

Post-operative care is usually routine. Certain cases will show a post-operative paresis of an arm or leg, but this usually disappears. Secondary signs of localized or generalized intracerebral pressure generally spontaneously subside; if not, a spinal tap should be performed. This procedure is almost specific for post-traumatic headache and for certain types of vertigo or dizziness in which the auditory or visual mechanism are uninvolved. Sequelæ like facial paralysis and eye and ear defects are often recovered from, even after apparent destructive lesions; however, if these manifestations show no improvement after a lapse of three months, some permanency is to be expected. Epilepsy is such a common manifestation in children that the onset of this condition after fracture of the skull must be looked upon with some suspicion. If, however, the head injury has been in the motor-cortical zone, and if the epilepsy is of the Jacksonian type, then the relationship is very much closer, especially if a period less than six months has elapsed since injury in an otherwise healthy child with untainted heredity. Clinically, in adults, post-traumatic epilepsy is so rare even when the fracture has been in the most susceptible region, and in cases operated upon for the removal of demonstrable epidermal, bone and dural scars, the outcome is so unsatisfactory that added difficulty is encountered in determining the actual cause. As the result of war wounds, we now know that epilepsy is a very rare sequel even with grossly destructive lesions. By analogy, then, we should look upon epilepsy as a rare end-result in children who have sustained skull fracture. The further the injury from the motor-cortical zone the less the probability of epilepsy; and concussion or intracerebral hemorrhage without gross bony injury are also unlikely factors. It is interesting to note that certain clinicians are of the opinion that the essential lesion of concussion is in the pituitary mechanism. Psychoses, mental impairment, and like conditions are very rare sequelæ in the absence of grossly destructive lesions. Cranial defects are much more likely to spontaneously close over than in adults, and thus in children we can confidently expect that such defects will rarely require surgical repair.

SUMMARY

(1) A combination of vault and basal injury can be expected in a very large percentage in which the injury has been severe, and when the violence has not been direct and localized in character; in the latter, vault fracture is more usual.

(2) The mortality in this series was 26 per cent., in which 5 per cent. followed vault fracture, and 10 per cent. basal and 11 per cent. combined vault and basal injury; stated in another way, involvement of the base gave a mortality of 21 per cent., four times that of the vault. If associated injuries are excluded, our mortality is only 17 per cent.

(3) Early death (within forty-eight hours) was due to the head injury or associated injury; thereafter infection in the form of meningitis, often pneumococcic, was the chief factor. Sixteen of our cases died within twenty-four hours, four within forty-eight hours; this means that over three-fourths (76.7 per cent.) of fatalities occurred in the first two days.

(4) Fifty-one per cent. of the quoted cases involved the vault with a mortality of 5 per cent.; 17 per cent. involved the base with a mortality of 10 per cent.; 32 per cent. involved base and vault with a mortality of 11 per cent.

(5) By comparison with adults, children have a 25 per cent. better chance for life with an equal grade of skull injury.

(6) The number of cases requiring operation is relatively small; in this group 12 per cent. were operated upon.

THE VALUE OF DAKIN'S SOLUTION IN THE TREATMENT OF THORACIC EMPYEMA

BY ABRAHAM O. WILENSKY, M.D.

OF NEW YORK, N. Y.

FROM THE MOUNT SINAI HOSPITAL, NEW YORK

THE use of Dakin's solution in the post-operative treatment of empyema thoracis has in the last few years received a very wide application. The principles and technic, as developed by Carrel, are employed for this purpose. It is hoped to secure a complete sterilization of the empyema cavity with the object of secondarily closing the outer wound; in that way the length of time necessary for complete cicatrization of the wound is said to be considerably diminished. This, in short, is the aim and aspiration of this adjuvant method in the treatment of empyema.

In actual practice empyemata of the thorax may be roughly classified as belonging to one of the following groups:

1. The Localized Empyemata. This group includes the relatively small cavities: these are single, are not marked by any complication of contour, and, because of these factors, are most readily subject to obliteration by the progressive expansion of the pulmonary parenchyma.

2. Multiple Empyema Cavities. More than one cavity—usually two or three—are present and are distinct from one another. Each is drained by a separate incision. Each represents by itself the characters of the cases in the first group.

3. Complicated Empyema Cavities. These result from the cases similar to those in the second group in which a communication is established between some or all of the individual cavities. When the communications are relatively small there are always disturbances of drainage, and revisions of one kind or another are necessary before proper drainage can be instituted.

In other cases a single large cavity is noted for its irregularity of contour; the latter results from the loculation or division of the major cavity, either because of the nature of the original provocative process, or because the communications between several independent cavities are very large. If the morphology of the interior includes a shelf formation, disturbances of drainage are frequent but are not insuperable difficulties in the way of healing.

4. Empyemata with Total Collapse of the Lung. These are especially important because, to my mind, they indicate fairly positively one of two things: (a) That the empyema was produced by a sudden rupture of some purulent focus within the lung parenchyma which permitted a free communication between the potential intrapleural space and the bronchial tree and resulted in the formation of an acute pneumothorax; the lung then immediately collapsed: (b) or because of the presence of a broncho-pulmonary fistula,

the total collapse of the lung was a somewhat more gradual process due to disturbed mechanical conditions such as I have described on a previous occasion. The important point is that in either case it presupposes the presence of a broncho-pulmonary fistula at some time of the history of the empyema.

The fact that the communication may not be demonstrable at any given moment does not negative the assertion that such a communication exists at the time of examination, or that it had been present at some previous time; for these fistulae may not be possible of demonstration because they are situated at some inaccessible portion of the cavity, or because they are extremely small, or because by that time they are, perhaps, even temporarily or permanently closed.

5. Empyemata in Which Broncho-pulmonary Cutaneous Fistulae are Demonstrable at All Times. This group includes cases of empyema which complicate or are complicated by pulmonary abscess.

The proper employment of the Carrel-Dakin method includes the following points in technic: (1) The removal of all sources from which continuing or repeated reinfection may take place; (2) complete asepsis in the dressings; (3) rigid attention to all details; (4) chemically correct solutions; (5) fairly intimate contact between surface to be sterilized and the antiseptic solution.

1. The complete removal of all sources from which continuing or repeated reinfection may take place. This is generally not possible for the most part because of the nature of the primary provocative illness and partly because of the deteriorated general condition of the patient. Very many times it is not feasible, nor advisable, to do more than the simplest of drainage operations primarily; one then depends upon nature and the natural recuperative powers of the patient for the removal of the primary infecting process.

In the post-operative period there are several other important sources from which the empyema cavity can be constantly reinfected. One of these resides in small foci of infection retained in the walls of the empyema as the granulation tissue by its accumulation gradually obliterates the cavity. Many times these foci heal in completely and form no nidus from which the empyema cavity can be reinfected. But many times more these foci undergo suppuration and, having burst, discharge their contents into the empyema cavity and so serve to renew the infection. Such foci may be in the parietes or in the visceral wall. I feel quite sure that some of the late recurrences are due to reinfections of a healed empyema cavity in which the source of the reinfection resides in one of these retained foci.

A very important source of reinfection is implanted in the ribs whenever these are resected for the purpose of securing "more ample" drainage. Quite regularly the exposed ends of the ribs are infected and an osteomyelitic process is set up; that part of the rib in which the latter process is active forms a very important nidus from which bacteria are constantly being discharged into the empyema cavity. This forms a most distinct disadvantage to the routine practice of rib resection. The difficulty is sometimes present even with intercostal incisions. In the latter the pressure of whatever drain-

DAKIN'S SOLUTION IN THORACIC EMPYEMA

age apparatus (tube, canula, etc.) is employed frequently results in a baring of an area of rib. Infection then readily enters, and, until the resulting sequestrum separates, a nidus is present for a continuing reinfection of the empyema.

A further source for reinfection is furnished by the presence of unrecognized abscesses, which are either draining insufficiently or not at all, in relation with the empyema cavity. The important varieties of this include the pulmonary or subdiaphragmatic abscesses. I do not know for certain what effect a recurrent pulmonic consolidation would have upon the empyema. The many experiences which I have had never seemed to include any particular manifestation which could be referred directly to the empyema, and, for that reason, I am inclined to believe that any new or recurrent focus of consolidation in the lung in intimate relationship to the empyema would not provide any source from which reinfection could take place.

2. Chemically correct solutions. The method of preparation of Dakin's solution has been fairly well standardized, and it should not be a matter of difficulty to secure correct solutions. Meticulous care is, however, essential that the latter have been freshly prepared, and constant testing is necessary to make sure that no material amount of the chlorine content has been lost.

3. An intimate contact between solution and surface to be sterilized. In the instillation of Dakin's solution into the empyema cavity there are wide differences in practice among all of the men, especially as regards the amount of fluid to be employed. Some use a comparatively small amount—10 to 15 c.c.—others use relatively larger amounts; many use an arbitrarily chosen quantity—usually about 100 c.c.—or the quantity is determined by the length of time the fluid is allowed to flow into the chest. Such practice is characterized by a certain timidity and lacks the precision which is a highly desirable factor. Inasmuch as it is very essential to secure an actual contact between antiseptic solution and the entire surface extent of the cavity to be sterilized in order to secure the actual sterilization, it is necessary in some way to employ the method with this object in view. Many employ a number of Carrel instillation tubes which, being stiffened with wire, are made to reach all parts of the cavity; the fluid flowing inwards is thus made to reach all surfaces; the amount of solution is, however, comparatively small, the contact of fluid and wall is only present for a few seconds and thereafter the fluid settles to the bottom of the cavity and a relatively large part of the interior is not in contact with the solution.

I make use of a large tube for drainage which is coupled with the suction apparatus. The tube leading from the chest to the collecting bottle is made to connect by a T-tube with the reservoir containing the Dakin's solution. The total capacity of the empyema cavity is measured with water and noted. The amount of Dakin's solution which is instilled at two-hourly intervals is equal to a few cubic centimetres less than the measured capacity. At the appropriate time the suction is blocked off with a clamp and the Dakin's solution is allowed to run in to the amount indicated. Inasmuch as the effect of the free chlorine liberated from the solution is only operative for a com

paratively few minutes, there is no necessity for allowing the solution to remain in the thorax for any undue length of time, and at the end of fifteen minutes the suction is reëstablished and the entire contents are evacuated from the chest. The suction is then allowed to continue until the next instillation. If desirable, the procedure can be repeated at hourly instead of two-hourly intervals.

It seems to me that this method is most satisfactory for assuring an intimate contact of antiseptic solution and surface to be sterilized. The large amount of fluid employed, as I have indicated, flows easily into the main cavity; it flows just as easily through any narrow or wide communication into any subsidiary loculi or around any obstructing adhesion; it makes contact efficiently with smooth, or distorted, or irregular cavity walls and with that of any subsidiary cavities; it remains in contact for the full time for which the fluid is of any use.

4. A very rigid attention to asepsis in the dressings of the wounds is extremely necessary. It is futile to make use of the antiseptic solution if with each dressing the wound is contaminated anew from the outside.

5. A rigid attention to detail. All of the factors indicated as being necessary to the proper carrying out of the technic are extremely essential; they must be persevered in; and even a slight deficiency in any one particular suffices to cause a breakdown of the entire method.

The presence of a broncho-pulmonary fistula of any magnitude makes the use of any solution in which free chlorine is the essential ingredient impossible of application owing to the "gassing" of the patient by the liberated chlorine gas. This rule does not, however, always hold true. I remember several patients who showed a moderate amount of distress from this irritation and, if I had followed the usual practice, I should have immediately abandoned the irrigations as part of the after-treatment. On subsequently repeating the irrigation in the same patient I was surprised to note the absence of any irritative signs, and thereafter the solution was tolerated very well. I remember in a number of other patients that signs of chlorine irritation were apparent at late periods of the post-operative course, which were present on only one, or, at most, several occasions in each patient, but which were not sufficient to deter us from continuing the use of Dakin's solution. The probabilities are that minute fistulæ were present which in some way were quickly closed, or which, because of their tortuosity or other mechanical obstruction, did not always permit any of the solution to enter the parenchyma of the lung. Perhaps the irritation of the chlorine was itself effective in closing the fistulæ because of the inflammatory swelling of the tissues making the sinus tract. At any rate, if the initial trial of the solution is followed by embarrassment, the effect ought to be corroborated by a second instillation before the irrigations are definitely abandoned.

There is a great deal of difficulty in making an accurate determination of the sterility of the cavity. The smear method is not at all reliable, not only because of the possibilities of error while looking through the smear, but be-

DAKIN'S SOLUTION IN THORACIC EMPYEMA

cause it is common knowledge that many colonies of bacteria will grow on media when no organisms are visible in the smear. Cultures are always necessary. In any case, however, the sterility of the outer wound is quite easily established. Similar possibilities are present with all of the relatively small cavities in which it is physically possible to reach all parts from which to secure specimens. When the cavities are very large or are marked by irregularities of contour it is not possible to reach all parts for specimens; and while seemingly all the areas from which specimens are obtained are sterile, others may very likely be present which harbor many organisms.

It is usually said that an absolute sterility of a wound is not necessary for the final stage of the Carrel-Dakin technic, namely, the secondary suture. While this is quite true for ordinary wounds, experience seems to show that it is not so with empyema cavities. These must be absolutely sterile for the suture to succeed. When the outer wound is closed, a vacuous cavity—a pneumothorax—is left; even a very few bacteria in such an environment seem sufficient to cause a reaccumulation of purulent exudate and a breakdown of the method. This probably explains many of the failures after secondary suture of the outer wound.

For the purpose of our argument it is assumed that the method is most properly and efficiently employed as far as is humanly possible. Under these conditions it behooves one to take cognizance of the sources of failure which are inherent because of the nature of the diseased process or which occur secondarily either as a result of the operative procedure or unavoidably accompany the healing. In the first of the groups segregated above—the simple, comparatively small and uncomplicated cavity—conditions are ideal for the method. It is easy to distribute the fluid to all surfaces; it is simple to maintain asepsis and determine when the cavity is sterile; sources of reinfection are at a minimum or are absent entirely. This variety of empyema is ideally suited for sterilization and actual practice bears this out. In Group Two similar results are obtained.

In Group Three the difficulty lies in securing the antiseptic effect upon the entire surface to be sterilized and in securing adequate drainage. The latter, according to our premises, is one of the obstacles to the successful employment of the method. Such complicated empyemata can heal, but experience seems to demonstrate beyond doubt that under such conditions the value of the antiseptic solution is very doubtful.

In Groups Four and Five the probable or certain presence of a bronchopulmonary fistula introduces a definite source from which a constant reinfection of the empyema cavity can take place. In the face of this complication the use of any antiseptic solution does not result in any sterilizing effect.

Aside from the sterilizing effect of the antiseptic solution one notes in all cases a purely palliative effect on the physical characteristics of the wound; much of this effect is of a purely mechanical nature. The amount of discharge rapidly lessens; necrotic tissues separate much more quickly; the granulating surfaces assume healthy aspects; fever disappears unless there

be present some complication capable of producing a febrile reaction; all of these, while extremely valuable, are but incidental to the main object of the method, namely, the sterilization of the cavity.

It seems, therefore, that in actual practice the use of the antiseptic (Carrel-Dakin) method in the treatment of empyema wounds has but a limited use. The method is not feasible in the presence of any source of reinfection (insufficient drainage of any kind, osteomyelitis of the rib, etc.), in the presence of any communication with the bronchial tree, in empyemata other than the simple pyogenic varieties, in empyemata whose contour is other than the simplest, or in empyemata the mechanical conditions of which are not conducive to a reasonably prompt healing (collapsed lungs). The method is very useful in the relatively small minority of small encapsulated empyemata and which do not suffer any of the drawbacks or complications previously indicated.

Under even these ideal conditions the method has not, according to my experiences, shortened materially the length of time necessary for the complete cicatrization of the wound. This is probably due to a variety of causes: (1) Such constant care is necessary in carrying out the details of the dressings that even in the best of hands breaks of technic are constantly occurring. As soon as these do occur the even progression of the healing is disturbed and what little time is gained previously is subsequently lost because of this disturbance. (2) Experience has shown that it is wisest not to suture secondarily the outer wound because of the numerous recurrences, but to allow the outer wound to close spontaneously after the cavity is supposedly sterile under a dry or other innocuous dressing. This practically reproduces ordinary conditions and healing then depends as much on the mechanical conditions of the cavity walls as it does on anything else. If the outer wound, having been sutured secondarily, is followed by a reopening, not only is time not gained, but a great deal of time is lost inasmuch as all of the original curriculum must be repeated.

One cannot help but gain the impression that in the cases in which the use of Dakin's solution is satisfactory, a healing similar in all respects would be obtained without the use of this antiseptic solution if the same meticulous care were exercised in the post-operative management as is necessary according to the precepts of the method.

The problem with the chronic empyema sinuses is not materially different. In actual practice many of these are due to manifestly glaring faults of technic, which result mostly in insufficient and improper drainage. When these are corrected healing proceeds with a fair degree of promptness. When the use of Dakin's solution is contemplated, the physical characteristics of the diseased process and of the empyema sinus and cavity come into play in exactly the same manner as was previously outlined in this communication in regard to the acute and subacute varieties of the disease. In the face of insuperable obstacles to the spontaneous closure of the thoracic sinus—of which the main mechanism is a constant reinfection of the cavity—Dakin's solution does not seem to produce any beneficial effect.

PRIMARY CLOSURE OF THE URETER AND RENAL PELVIS AFTER NEPHROLITHOTOMY

BY LE GRAND GUERRY, M.D.

OF COLUMBIA, S. C.

My attention was first forcefully directed to the question under consideration by a paper in the Louisville monthly *Journal of Medicine and Surgery* by Abell. The paper was published some time in 1907 and demonstrated conclusively, to my way of thinking, that primary closure of the ureter and renal pelvis, when removing stones, was surely the operation of choice in properly selected cases: notice, please, the expression, properly selected cases. Unless this qualifying phrase is borne in mind, confusion as to our position will certainly arise.

Urologists, by greatly improved methods of technic and equally improved instruments, are able to remove the majority of stones from the lower end of the ureter without an open operation. Certainly, within reasonable limits, this method should be given a fair trial.

We must also remember that a large percentage of all stones in the ureter are passed voluntarily by the patient without any operative aid, and this paper concerns itself solely with the group of cases in which, for one reason or another, operation is deemed best.

In a very extensive review of the literature on this question, during the last ten years, it was quite surprising to find how frequently and how very successfully the method of primary closure has been and is now practiced. For example, we find Israel, Albarran, Jeanbrau, Tuffier, Cabot, Crile, Young, Mayo, Judd, Murphy, Kelly and many others practice primary closure.

We can think of no reason why, when the individual case is carefully studied, the ureter should not be closed immediately. Of course, there are cases in which it would be bad surgery to attempt immediate suture, the point being that the grounds for closing in one case and not closing in another case are fairly obvious and easy to ascertain.

Judd, in a personal communication, says: "I feel confident that I have closed the ureter in fifty cases and have never known any difficulty to arise from it. In a few instances there was drainage of urine in spite of closure, although in a large percentage the wound has healed practically by first intention."

The ureter is a patent tube with dependent drainage naturally all of the way from kidney to bladder, the very best possible kind of drainage, and the simple presence of a stone does not constitute, within itself, any sufficient reason for drainage. Take, for example, a perforating wound of the intestine; we know that such a wound is infected, and yet, while

we may drain the abdominal cavity, one would hardly attempt to drain from the site of each individual perforation.

Given then a stone in the lower ureter, all reasonable efforts should be made to remove the stone without open operation. There are, however, fairly definite and clear limitations to the amount of effort which should be made to remove the stone through the cystoscope.

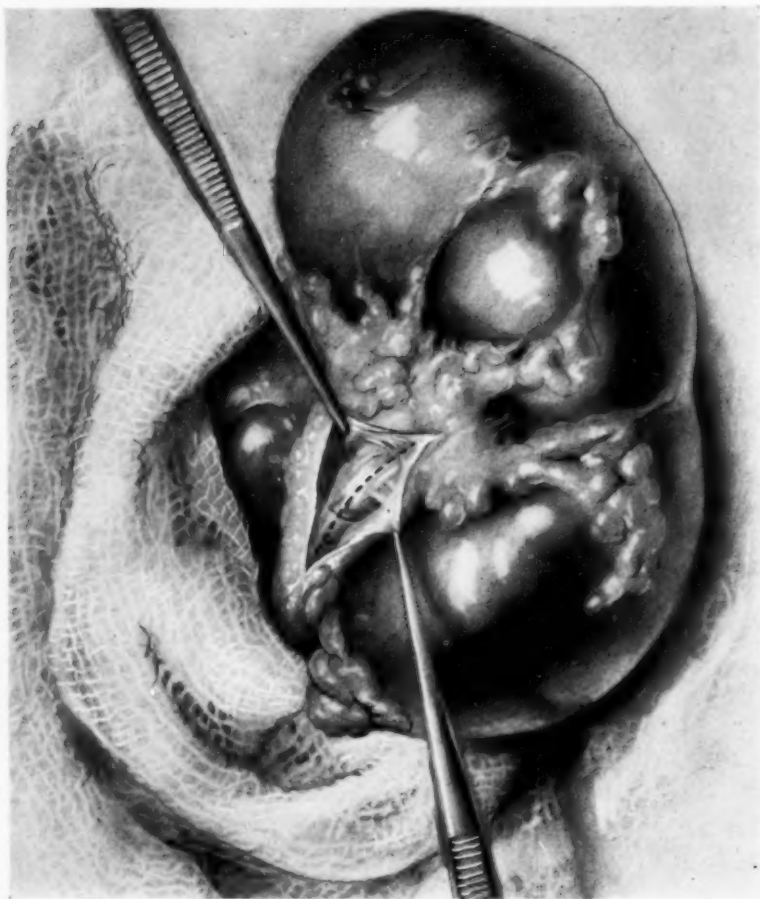


FIG. 1.—Shows kidney exposed, incision through the capsule and muscular layer, down to mucous membrane, the dotted line showing the incision to be made through the mucous layer to stone.

In a paper by Judd, read before the Southern Surgical Association, December, 1919, and published in the *ANNALS OF SURGERY*, February, 1920, page 129, he gives the following contraindications by Braasch as to efforts to dislodge stones: (1) A stone 2 cm. or more in diameter. (2) Ossification with continuous obstruction. (3) Acute renal infection. (4) The patient's intolerance to cystoscopic manipulation. (5) Anatomic deformity.

If the renal infection is severe, intra-ureteral methods should not be

PRIMARY CLOSURE AFTER NEPHROLITHOTOMY

attempted, and operation should be undertaken with the idea that it may be necessary to remove the kidney. These contraindications, while they are known to all of you, have added emphasis by the weight of this authority's sanction.

One must ever bear in mind what may happen from the continuous pressure exerted on the kidney by obstruction of the ureter, and that it is quite possible to have from this cause a permanent hydronephrosis or pyelonephrosis.

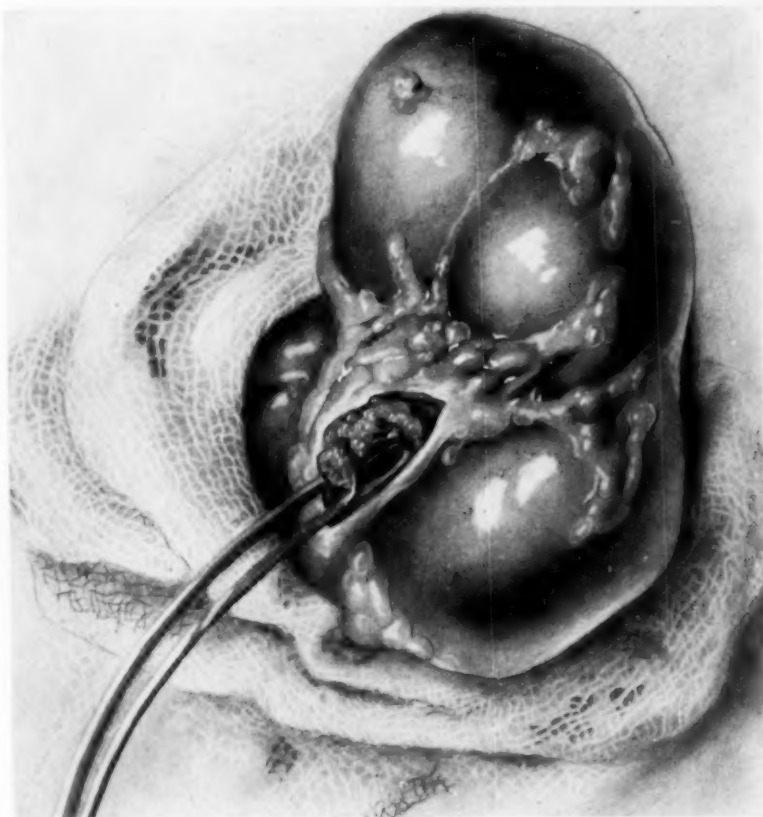


FIG. 2.—Shows the stone exposed and being extracted with long forceps, especially designed for this purpose.

Face to face then with a given case, in which the open operation has been decided on, there are four primary reasons, the presence of any one of which constitutes sufficient reason for drainage as against primary closure: First, a stricture of the ureter of such calibre and density as seriously to encroach upon the size of the ureter. In my experience, however, this is a very rare condition and at the present time, amongst urologists, is a question of lively debate. Second, the presence of extensive infection. This condition constitutes a real contraindication and

is one which we do meet with occasionally. Third, inaccessibility of the field of operation. Unless the field of operation can be rendered accessible and brought within ready control of the surgeon, it is quite difficult, if not impossible at times, to practice immediate closure. Fourth, at times the patient's condition may be so serious as to make inadvisable anything but the very minimum of manipulation. Personally, I have



FIG. 3—Shows the stone extracted, interrupted sutures placed and ready to be tied. Note, particularly, that these sutures do not include the mucous membrane.

had one case in which the patient was in coma from obstruction to both ureters by stones. The stones were removed under local anæsthesia; no suture of ureter was attempted; drains were placed to site of each operative field, and the patient died within thirty-six hours in uræmic coma.

Such, then, and very briefly, are the reasons for drainage and non-closure; the same grounds apply with equal force to stones in the renal pelvis.

PRIMARY CLOSURE AFTER NEPHROLITHOTOMY

Conversely, then, in the absence of the above stated contraindications, our position is: that the ureter and renal pelvis should be closed primarily.

One will find, I believe, when fairly considered, that primary closure of the ureter and renal pelvis, without drainage, is a safe, sane and sound surgical practice, thoroughly consistent with the underlying principles of pathology.

Those who do not subscribe to the position of primary closure main-



FIG. 4.—Shows complete closure of incision in the pelvis. It also illustrates method of drainage without putting the drain to suture line. This plan may be adopted in certain cases in which you are willing to close primarily but would feel safer in using drain.

tain that the mortality is just as low, and that the patients will recover just as well as if suturing was immediate, and this, in a very real sense, is quite true. We insist, however, with all of the emphasis at our command, that convalescence is shortened, the mortality rate is just as low. When the question of the patient's comfort is considered, there is a very great difference, don't you think, between the patient, on the one hand, with a perfectly dry, comfortable wound, and, on the other hand, a case lying in bed with a cold urine-soaked dressing, lasting anywhere from one to

six weeks, the mortality rate in the primary closure being just as low as in the cases which are drained.

In all of this discussion we must remember that the open operation for removal of ureteral and kidney stones has an exceedingly low mortality rate and the very best end-results.

So much for the argument. Now for the facts based on our personal experience; for after all, we are not nearly so much interested in main-



FIG. 5.—Shows field of operation for exposure of ureteral stone. The ureter has been exposed and held well into position in the field of operation, by two gauze tips, which serve admirably as retractors. Attention is particularly directed here, as in Fig. 1, to proper placing of suture, the fascia capsule and the muscular layer being included in the stitch, but not the mucous membrane.

taining a certain position as we are in adding our personal experience to the primary closure side of the question. The facts are as follows: We have practiced primary closure in a series of nineteen cases, not a very large series, still quite sufficient to be suggestive. Of the nineteen cases, eleven were men and eight were women. Twelve times we have closed the ureter and seven times the renal pelvis. Of the twelve cases in which the ureter was primarily closed, there was one case in which the sutures came out, and the ureter leaked just as much and just as long as if it had never been sutured, the basic fault here being one of surgical judgment

PRIMARY CLOSURE AFTER NEPHROLITHOTOMY

rather than one of method, for we did violence to the rule of reason, as pointed out in contraindication two and three. The patient was a very stout male in which there was marked infection around the stone, and the field of operation was so inaccessible as to make closure very difficult.

Good judgment in this case would have dictated not closure but drainage. In one other case in this group there was escape for four or five days of a very small amount of urine, about 20 per cent. of what would have escaped had closure not been made.

We have, then, in the group of twelve ureteral cases, one complete failure, one 20 per cent. failure, and ten cases in which the wound healed by complete primary union. Surely a result worth while and pregnant with food for thought.

In the group of stones in the renal pelvis there are eight cases, six of these healed by complete primary union, and two cases, while they showed some leaking, were a marked improvement over the method of non-suture, since both of them leaked very little and closed within a week.

The ureter should be opened parallel to its long axis; every effort must be made to preserve the connective-tissue capsule of the ureter and the sutures so introduced as never to include the mucous membrane. The connective-tissue capsule and its use and preservation is the most essential element in success.

The method of technic and the things to be considered in a purely operative way are best shown in the illustrations.

Since writing the above, we have had two more cases of stone in the ureter, in which we have been able to practice primary closure after removal of stone, without drainage, and in both cases we have had perfect primary union. The addition of these two cases makes our total cases number twenty-one. The figures show fourteen cases of ureteral stone with twelve successful primary closures; one complete failure, and one twenty per cent. failure. If the points about the proper use of the connective tissue and fatty capsule of the kidney and ureter, in making the closure, are borne in mind, the results will be uniformly good; it is also vitally necessary not to include in the suture the mucous membrane. It is very remarkable what an extensive injury to pelvis of the kidney can be closed immediately with perfect results, when the fatty capsule is used to reinforce the suture line.

Our rule is not to drain these cases unless it is clearly indicated.

URETERO-URETERAL ANASTOMOSIS

A MODIFICATION OF VAN HOOK'S TECHNIQUE

BY J. D. McEACHERN, M.D.

OF WINNEPEG

LECTURER IN SURGERY, UNIVERSITY OF MANITOBA

THE operation of uretero-ureteral anastomosis is sufficiently rare to warrant reporting all cases in detail, especially those in which end results are recorded. I have to report the following case.

Mrs. W., aged forty-three, consulted me on July 16, 1919, on account of the presence of an abdominal tumor. Examination revealed multiple fibroid tumors of the uterus. The mass extended two inches above the umbilicus and was impacted in the pelvis. The abdomen was about the size of a six months' pregnancy. The patient complained of pain in the back and irregular and profuse bleeding from the uterus. On July 18th operation was undertaken for the removal of the tumor. The mass was found firmly impacted in the pelvis. It fitted the pelvic canal so tightly that it was impossible to pass the fingers down between it and the bony wall. The veins of the broad ligament were greatly dilated. A first attempt to dislodge the tumor from its resting place failed. The broad ligaments were then opened up on both sides. The dissection was hampered by bleeding from the thin walled dilated veins. In going down on the right side, a fibroma the size of a grapefruit was encountered jutting out at right angles from the cervix. At this point a second attempt was made to lift the mass out of the pelvis which was successful. When this was done it was found that the right ureter had been torn almost completely across, the ends being held together by a mere shred of tissue. A hæmostat placed on a vein in the right broad ligament, close to the anterior surface of the tumor already referred to, had grasped the ureter in its point and the displacement of the mass when it was lifted out of the pelvis had resulted in the ureter being torn. The abnormal position of the right ureter in this case was brought about by this intraligamentous fibroid in its growth; the bladder being crowded over into the left half of the pelvis, and the ureter carried forward and inward until it lay across the anterior convexity of the tumor near the median line. The distortion of the pelvic contents was further aggravated by a rotation of the whole tumor mass; the broad ligament on the right side coming off the antero-lateral margin of the growth, and on the left side from the postero-lateral margin. The hysterectomy was completed and after excising the injured portion of the ureter an end-in-side anastomosis was made as follows:

The distal portion was ligated one-eighth inch from the end with No. 1 chromic catgut. A longitudinal slit was then made in its lateral

URETERO-URETERAL ANASTOMOSIS

wall beginning one-fourth inch below the ligature. The end of the proximal portion was then cut across at about an angle of 130 degrees; the acute angle being on the lateral side. Two needles armed with a single thread of No. 00 plain catgut were passed from without inwards through the lateral wall of the upper portion of the duct one-eighth inch from its end. A like suture was passed in a similar manner through its medial wall one-sixteenth inch from the end. The needles threaded on the lateral suture were then passed through the slit in the distal portion and carried down the tube for a distance of one-eighth inch beyond the lower end of the slit, where they were brought out side by side. The needles threaded on the medial suture were also passed in through the slit in the distal portion and brought out side by side at a point opposite the middle of the slit (see cut). By gentle manipulation the upper tube was drawn into the lower and the stay sutures tied. Two sutures of fine plain catgut, placed down to the mucous membrane on the anterior and posterior aspects of the anastomosis as shown in the

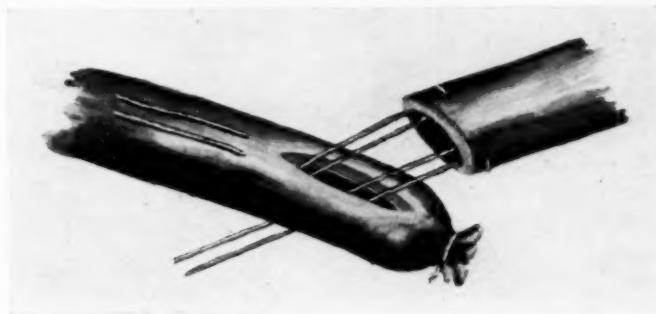


FIG. 1.—Stay sutures in position ready for manipulating upper portion into lower.

drawing, completed the union. The ureter was dropped back in position and the peritoneum carefully closed over it. A cigarette drain was placed extraperitoneally down to the site of anastomosis and brought out on the anterior abdominal wall in the semilunar line.

The patient made a good recovery without leakage of urine. The cigarette drain was removed on the sixth day.

On October 29, 1920, one year and three months after operation, the patient returned for examination. She states that her general health has been perfect and that she has been entirely free from pain in any region since the operation. Cystoscopic examination showed the bladder to be normal in appearance. Both ureteral orifices were observed to be functioning normally. Catheters were placed in both ureters. The catheter in the right ureter was arrested at a point 15 centimeters from the ureteral orifice. (This point would correspond roughly with the point of anastomosis.) Clear urine dripped normally from both catheters. The right catheter was withdrawn 5 centimeters and the same result obtained. An intramuscular injection of phthalein appeared simultaneously in the urine from both kidneys in 8 minutes. The catheterized specimens from both kidneys were free from pus or bacteria and contained normal and approximately

equal amounts of urea. The patient would not submit to a pyelogram being made.

COMMENT.—The anastomosis here described is a modification of the end-in-side method originated by Van Hook nearly thirty years ago. There are, however, some important points of difference. The end of the upper

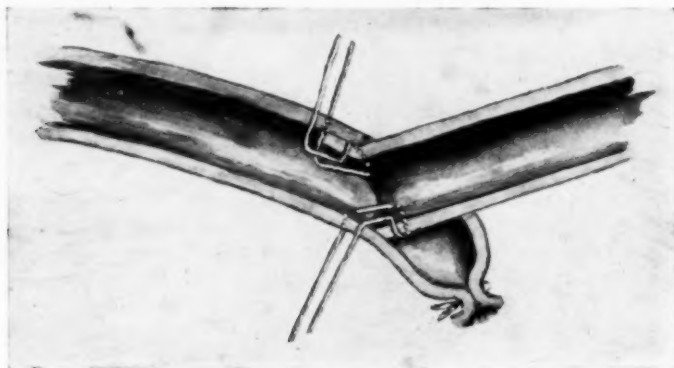


FIG. 2.—Upper portion drawn into lower. Stay sutures ready for tying.

portion is not slit, and its medial wall is carried right across to the medial wall of the lower portion in an attempt to cut off the blind end by directing the flow of urine down the distal portion. This is accomplished without invaginating the upper tube into the lower, thus avoiding the narrowing of the lumen that the invagination method produces. The stay sutures are two in number and are brought down the lumen of the upper tube; the object being

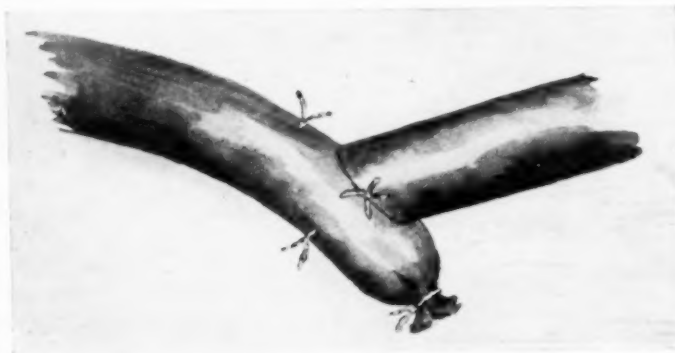


FIG. 3.—Stay sutures tied. Single suture of plain cat gut on each side completing the anastomosis.

to overcome any tendency of the cut mucous surface to curl up and become adherent.

The division of a ureter must in the vast majority of cases be considered a surgical accident, as only rarely is the ureter divided on account of pathological conditions involving it. The operation for restoring the continuity of the

URETERO-URETERAL ANASTOMOSIS

duct is therefore largely an emergency one. For this reason the technique should be sufficiently simple for the average surgeon to carry out successfully.

Failure is most likely to result from stenosis at the point of anastomosis. Alksne¹ in his experiments carried out on dogs has shown that stenosis may be caused by traumatic edema as a result of operation. To minimize this danger the tissues of the ureter must be handled with the greatest care, and as few sutures as possible used. It is essential that the slit in the distal portion be the right length. If it is too short the lumen of the upper portion will be encroached upon at the point where it passed through the wall of the lower portion. If it is too long, additional sutures will be required to close the vent, thus increasing the danger from traumatic edema as well as from leakage of urine. Any type of operation which produces an immediate narrowing of the tube at the point of anastomosis (as invagination of the upper tube into the lower) must favour the development of stenosis. Leakage of urine probably means failure. The immediate danger to the life of the patient from extravasation of urine is great. The defect must be closed by granulations, and the later contraction of the scar will almost surely result in stenosis, hydro-ureter and hydro-nephrosis.

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(Animal experiments.)

DIVERTICULA OF THE JEJUNUM

BY HUGH N. MacKECHNIE, A.B., M.D., C.M.

OF CHICAGO, ILL.

THIS case of diverticula of the jejunum, together with a brief review of the literature, is presented with the object of stimulating more careful clinical and laboratory studies leading to a diagnosis of a condition in which too often we are content to rest with a diagnosis of stasis without going into the more important points of etiology and pathology of such. In the more chronic type we adopt Micawber's attitude of "waiting for something to turn up," and when the acute conditions arise we are unable to make the necessary examinations and tests.

This patient was referred to me by my associate, Dr. Paul Kelly, who had her under observation. Her history is as follows:

Mrs. L., housewife, aged forty-three, married twenty-three years, complains of (a) constipation, recently severe and accompanied by much pain, gradually growing worse; occasionally a little blood in stools for past one and one-half years, with defecation becoming more and more difficult and unsatisfactory; (b) some pain through the abdomen, especially during the last two and one-half months, which is more pronounced with efforts to defecate; (c) gas in bowels for several years and growing worse; (d) vomiting spells occasionally, becoming more persistent in the past three months and accompanied by much belching; (e) prominence of lower abdomen, which is rather flabby and flaccid; (f) poor appetite and bad taste in mouth with a sweetish, offensive breath.

Family history is negative. Patient has two children, twenty and twenty-one years of age. She had one miscarriage eighteen years ago. During the last ten years she has had more or less stomach trouble. Five years ago she had a severe bronchitis for three weeks; no tuberculosis was found at this time. She has always had headaches. She had pneumonia at the age of twenty-three; never had typhoid or malaria.

Physical examination on August 10, 1919, showed the patient emaciated with fairly moist, dirty, sallow skin. There was no cachexia or jaundice. Her expression was dull; tongue dry, slimy and red. Heart, lungs and reflexes were negative. The blood pressure was 100 systolic and 60 diastolic. Urine examination was negative. Rectal and vaginal examinations revealed nothing but a few small hemorrhoids.

The abdomen was somewhat distended and tympanitic. The walls were very thin. There was no dullness, and no tumor masses could be palpated. Peristalsis was plainly visible, particularly low down on the left side. The stomach was somewhat distended and ptosed. There was much belching upon examination. The vomitus consisted of a thin, sweetish, offensive light yellow fluid containing undigested food.

DIVERTICULA OF THE JEJUNUM

The stools were scanty, dry, hard, and dark, with an occasional streak of blood.

The patient entered the hospital August 18, 1919, but declined surgical relief. While in the hospital she did not sleep well, vomited all the food taken; diet had no effect on the condition. Rectal feeding was unsatisfactory because of lack of absorption and a very sensitive rectum and anus. After starving for forty-eight hours she became quite hungry, and the stomach and small bowel were emptied by vomiting. After a meal or two the vomiting recurred. There was very little pain or tenderness. The emaciation increased, the patient became toxic, and had a slight delirium. Her temperature remained normal, though the pulse rate was increased. The diagnosis made at this time was a partial obstruction of the bowel, probably of a nonmalignant nature. The patient refused sigmoidoscopic examination and also the barium meal and X-ray, which subsequent events proved would have been of much value to us in settling our diagnosis. Operation was urged because of the increasing toxicity that gave promise of soon becoming serious.

September 9, 1919, three weeks after examination, the patient consented to operation. At this time there was little change from the previous examination except that the patient had had a number of severe vomiting attacks and was quite toxic and dull. A low midline abdominal incision was made, extending up to the umbilicus. No malignancy was found at any point. The pelvic organs appeared normal. The rectum, sigmoid and colon were normal, except for a rather increased freedom and prolapsed condition. There were no adhesions at any point. The appendix and gall bladder appeared normal. The whole gastro-intestinal tract was empty. The stomach was somewhat dilated and ptosed, but showed no pathology. The ileum was normal. The upper jejunum for about two and one-half feet was dilated to two and one-half inches in diameter, and on the mesenteric border were thirteen diverticula varying in size from that of a split pea to that of a pigeon's egg. The remainder of the jejunum was normal in size. The duodenum was equally dilated, and had one large diverticulum on the transverse portion and two on the descending, all three being on the mesenteric edge. No obstruction was found and no pathology other than this was present. As the condition of the patient was quite serious, no effort was made to excise the bowel nor to excise or replace the diverticula by invagination. In order that this part of the bowel might be eliminated from the intestinal canal and thus decrease the intestinal intoxication, a duodeno-jejunostomy with the Murphy button was performed, with the intention of excising the diverticula later when the patient recovered from the shock and toxemia. Unfortunately she did not recover. After coming out from the anæsthetic she suddenly collapsed and died three hours later.

At autopsy the specimen was removed. The duodenum and jejunum were markedly dilated. The intestinal wall for the full length involved by the diverticula was considerably thinned and the height of the rugæ decreased. The diverticula were all thin walled, collapsible, and

because of large openings were easily inverted into the intestinal canal, except some of the smaller ones. They were of the false type and most of them were in close proximity to the larger vessels. Microscopically there was almost complete absence of the muscular coats.

In recent years diverticula of the gastro-intestinal tract have been found by the surgeon at operation, and still more recently a number have been diagnosed by the röntgenologist in the course of routine intestinal examination. By far the larger number have been found at autopsy. There is a good reason for this, because most of the cases present no marked symptoms that direct our attention to the condition, and secondly, because the majority of the patients die of some condition quite independent of the gastro-intestinal tract.

The following is a brief résumé of those cases found in the literature to date.

COOPER, SIR ASTLEY,¹ 1844: A man, aged fifty, had died of liver disease with free fluid in the thorax and abdomen. At autopsy there were found multiple diverticula of the jejunum, false in type, varying in size from a pea to a walnut, lying between the layers of the mesentery. In the upper ileum there was a marked adhesion producing obstruction. The diverticula contained flatus, but no other intestinal contents. This patient also had bilateral inguinal hernia and a left femoral hernia.

CORNILLON,² 1869: A woman, aged thirty, died following placenta prævia. At autopsy she was found to have a single diverticulum of false type between the mesenteric layers. No further details are given.

OSLER, WILLIAM,³ 1881: A man, aged sixty-five, died of an acute enteric attack with melena which had no connection with the diverticula found at post-mortem examination. For years he had colicky pains and much "rumbling," but no constipation. He was found to have 53 diverticula in the jejunum, varying in size from a cherry to an apple, between the mesenteric layers. These were of the false type and contained fluid faeces.

MOORE, N.,⁴ 1883: A man, aged forty, died of bronchitis. At necropsy there were found three diverticula in the first three feet of the intestine and a congenital stricture in the mucous membrane at the beginning of the jejunum. These were of the true type and were found on the mesenteric border. There were no symptoms indicative of diverticula.

BUZZI,⁵ 1885: A man, aged seventy-seven, died of peritonitis following perforation of a carcinoma of the pylorus. At necropsy there was found a single diverticulum 23 x 32 mm. in size at the mesenteric border. It was of the true type. The author speaks of this as a misplaced Meckel's.

BUCHWALD AND JANICKE,⁶ 1887: A boy, aged six, on whom they operated for obstruction of the bowel due to cystic tumor of the jejunum, was found to have a diverticulum of the true type on the mesenteric side, probably congenital.

VIRCHOW, R.,⁷ 1890: At necropsy performed on a lean old man, were found many diverticula of the size of an egg, false in type. These were located at the mesenteric border and each had a large opening into the bowel.

EDEL, M.,⁸ 1894: At autopsy performed on a woman, aged seventy-three, there were found 7 diverticula of walnut to apple size on the mesenteric border, with blood-vessels coursing over them. There were many diverticula in the colon.

SEIPPEL,⁹ 1895: An autopsy specimen with sac-like protrusions near the lower end of the jejunum between the folds of the mesentery, one is about the size of a walnut, false in type with the muscularis absent and the mucosa folds absent. The intestine is wide and flabby. The mesentery is full of fat.



FIG. 1.—Enlarged duodenum with three diverticula, jejunum with thirteen diverticula.

DIVERTICULA OF THE JEJUNUM

GOOD,¹⁰ 1895: A necropsy specimen in a woman aged seventy-seven showed 6 diverticula in the jejunum and one in the duodenum. These were false in type, rounded, sac-like, between the layers of the mesentery, and over some of them vessels coursed. The intestine is wide and flabby.

HANSEMAN, D.,¹¹ 1896: A necropsy specimen in a boy, aged fourteen, showed a single diverticulum opposite the mesenteric border. In its apex was a small accessory pancreas.

A man, aged eighty-five, died of pneumonia. At autopsy there were found some 400 diverticula in the small bowel, mostly in the jejunum at the mesenteric border, near the larger blood-vessels.

GRASSBERGER, R.,¹² 1897: A man, aged seventy-three, died from perforation of a duodenal ulcer. At autopsy there was found a diverticulum in the jejunum of the false type at the mesenteric border. There were also one in the stomach, two in the duodenum, and many in the colon.

NICHOLS, A. G.,¹³ 1899, reports a pathological specimen of three feet of jejunum in which were 45 diverticula varying in size from that of a pea to a walnut. They were situated at the mesenteric attachment and consisted of hernias of the mucosa into the serosa without fecal contents. The patient was a woman, aged sixty-four, who had a bilateral inguinal hernia for thirty years and a bronchitis for twenty-five years.

FISCHER, M. H.,¹⁴ 1900: A museum specimen with a diverticulum, false in type, the size of a bean, within the mesenteric layers and with a small opening into the bowel.

GORDINIER, H. C. AND SAMPSON, J. A.,¹⁵ 1905: A woman, aged forty-five, had constipation with marked abdominal tenderness following a supposed attack of appendicitis three weeks previous, when she had severe abdominal pain radiating from the umbilicus followed by nausea and vomiting, a fever of 100.2, and great distention. There was a sausage-shaped mass to the left and a small mass to the right of the umbilicus. Catharsis and enemata removed most of the mass but the tenderness remained. At operation for the intestinal obstruction there were found 13 diverticula in 40 cm. of the lower jejunum and upper ileum. They were on the mesenteric border, had large openings, were false, and had large vessels coursing over each one. One was inflamed, producing adhesions to the colon and kinks in the bowel. This one was removed and drained. No others were invaginated, although it was possible with all. The patient made a recovery.

TAYLOR AND LAKIN,¹⁶ 1910: A woman, aged sixty-eight, died of pneumonia. At necropsy were found very many diverticula, ranging in size from a pea to a walnut. They lay between the layers of the mesentery, were false in type, and had well defined openings. There were also many diverticula in the colon.

BALFOUR, D.,¹⁷ 1913: A patient had been suffering for years with symptoms of ulcer near the pylorus. For this Balfour operated, intending to do a gastro-enterostomy. He found the fibrosis of a healed ulcer and also adhesions binding the mesocolon to the mesentery of the jejunum and to several inches of the ileum. There were 4 well-marked diverticula, one within one inch of the duodenum and three within sixteen inches of the duodenum. They were at the mesenteric border and varied in size from a hazelnut to a walnut. No other diverticula were found. The gastro-enterostomy produced a symptomatic cure.

LATARJET AND MURAD,¹⁸ 1914: A necropsy specimen of a woman, aged fifty, who had a single diverticulum in the jejunum, 2.5 x 5 cm. in size, false in type, on the mesenteric side in close apposition to the blood-vessel, with a large opening into the bowel.

BRAITHWAITE, V.,¹⁹ 1918: A necropsy specimen in a man of forty-five, who had died in Guy's Hospital of other conditions. He had 2 diverticula in the midpart of the duodenum and 60 in the first three feet of the jejunum. They were at the mesenteric attachment. The largest was 25 cm. in diameter.

CASE, J. T.,²⁰ 1920: A man, aged sixty-one, had complained for many years of an "indigestion." In the course of routine röntgen examination a diverticulum a few centimeters below the duodeno-jejunal juncture was diagnosed. At operation many diverticula were found at the mesenteric border. Resection was performed with recovery.

A man, aged seventy-three, had a diagnosis of multiple jejunal and upper ileum diver-

ticula. This man was later operated and the diagnosis confirmed, but further data were not given.

McWILLIAMS, C. A.,²¹ 1921: A man, aged seventy-one, had an acute abdomen of 24 hours' duration, with exquisite pain, vomiting at the onset, and several hours later followed by two large loose blood-free stools, and none after that. There were present mid-abdominal distention and tenderness, flatness in the flanks, but no ascites nor palpable tumor. Temperature was normal. A diagnosis of obstruction was made, but the patient died five hours later without operation. At autopsy the bowel was found distended and discolored, containing much blood. There were seven large diverticula in the jejunum, at the mesenteric border and along with the blood-vessels. There were two aneurisms of the abdominal aorta and a thrombosis of the superior mesentery artery.

TERRY AND MUGLER,²² 1921: A woman, aged fifty-nine, operated on for duodenal ulcer, was found to have 5 diverticula of the upper jejunum at the mesenteric side. Two were inverted. At a later date she was operated for intestinal obstruction due to an enterolith found in a diverticulum.

Diverticula of the upper intestinal tract may be acquired or congenital. In the latter all coats of the bowel are present although the muscularis may be thinned out and the folds of the mucosa may be obliterated. This group is typified by Meckel's diverticulum. The acquired type has a more or less atrophied or an absent muscularis and a thinned-out mucosa. It presents itself as a thin-walled, compressible balloon-like projection on the side of the bowel. This type is to be distinguished from spurious diverticula or cysts of the intestinal wall in which there is a thin-walled cystic tumor on the side of the intestine having no connection with the intestinal lumen.

Diverticula of the jejunum are found the least frequent of any diverticula in the gastro-intestinal tract. I have found in the literature only twenty-four cases recorded as such, which with my own make twenty-five. Of these seventeen were found at autopsy, the patient having died of other conditions not relative to the diverticula; five cases were found at operation for other conditions or without specific diagnosis; two cases were diagnosed by röntgen ray before operation and the diagnosis verified in the operating room; in one case the time of discovery was not specified.

ETIOLOGY. *Sex*.—Fourteen cases were males and nine cases were females and in two the sex was not specified. This might indicate that straining with an increased intra-abdominal tension was a factor.

Age.—The youngest was six, probably congenital and true; the oldest, eighty-five, probably acquired and false. Under fifty years there were seven cases; between fifty and eighty-five there were sixteen cases and of two the age was not mentioned. It would seem that the declining years with decreased muscle power had the false type as the more prevalent.

Location.—Twenty-one cases appeared at the mesenteric border and five were distinctly stated as being in close touch with the larger intestinal arteries; in other words, they are found at weak spots in the intestinal wall.

Other factors mentioned in this connection are, weak spots in the muscularis; cachexia following obesity; fatty infiltration of the muscularis; adhesions producing tension; developmental rests, such as accessory pancreas or epithelial pearls; decreased intra-intestinal pressure: decreased amount of

DIVERTICULA OF THE JEJUNUM

fibrous tissue to support the walls at certain points; varying size of blood vessels due to chronic heart trouble. **PATHOLOGY.** In the true type there is found evidence of chronic inflammation with infiltration and thickening of the wall, and occasionally engrafted thereon an acute inflammation.

In the false type the most of the diverticula show no evidence of inflammatory change. There is a thinning or obliteration of the muscularis and an obliteration of the mucosa folds with atrophy of the glands. In one case the diverticulum had become infected, the opening closed, with abscess formation, marked thickening of the walls and protective adhesions in the peritoneum. In two cases adhesions occurred between the mesocolon and the diverticulum due to inflammatory processes in the diverticulum. In several cases dilatation of the bowel occurred along with and above the diverticula. These conditions produced an ileus with its consequent toxemia. One had an enterolith form in the diverticulum and thereby produced an acute obstruction.

SYMPTOMS. Only seven of the recorded cases give a clinical history with evidences of abdominal trouble that might be considered incident to the diverticula. One with acute hemorrhage had suffered for years with colicky pains, much rumbling in the abdomen but no constipation. Another had an acute obstruction of the bowel by a cystic tumor of the jejunum, but no other evidence of intestinal disturbance. Another had an acute obstruction due to an enterolith forming in and protruding from a diverticulum. This was broken up and passed without further treatment of the diverticulum. In this case, eighteen months previously two large diverticula were inverted at an operation for duodenal ulcer. X-ray plates taken to diagnose the ulcer were subsequently studied, but no evidence of the diverticula could be found. One case had pain, nausea and vomiting, tenderness and distention, with two masses of impaction and grafted on this an infection with abscess formation, a history not unlike that of appendicitis. One had gastric distress for years, which was referred to the duodenal ulcer. As operation (gastro-enterostomy) relieved the condition, it is felt that the symptoms were not due to the diverticula. Another had an acute abdomen of twenty-four hours with pain, vomiting, distention, tenderness, small, rapid, irregular pulse and normal temperature. The patient died of thrombosis of the mesenteric artery, which probably produced the symptoms. In one case a diagnosis of chronic ileus was made on the toxemia, the intermittent constipation and diarrhoea, flatus and distention, the inability to retain food for any time, vomiting and in a short time hunger.

In the two cases diagnosed under X-ray, Case says that there was present a definite picture of a mass of fluid food or barium filling the lower part of the diverticulum and an air bubble filling the upper part, resembling the condition in the stomach on taking a barium meal.

It has been said that these conditions do not produce symptoms. A few that have been cured of symptoms without operative procedure on the diverticula, but by correcting other conditions, appear to substantiate this.

On the other hand, some cases, such as my own, appear to produce definite evidence of chronic ileus due to nothing else, while two others produce acute obstruction. It is possible that a further study of those with corrected pathology may give evidence of another though minor pathology in the form of the diverticula.

TREATMENT. The treatment of this condition may be divided into two classes: that of the simple, uncomplicated diverticulum, and that of diverticulum with complications. In the first group are the cases showing evidences of chronic ileus and toxemia; in the second are those with acute obstruction, abscess or perforation and peritonitis.

That diverticula *per se* do not produce symptoms may be granted. That they may be present for some time without creating symptoms is undoubtedly true. On the other hand, it is certain that they act as retainers for fermenting food stuffs, and it is equally certain that they tend to produce an ileus and a dilatation of the bowel with which comes the train of symptoms incident to a toxemia.

In these conditions of chronic ileus and toxemia, therefore, we must always look for diverticula as a causative factor.

As to medical treatment, it seems illogical that there should be one. Roberts²³, however, has produced some excellent palliative results in diverticula of the colon by the introduction of the barium enema. This material crowds out the fermenting fæces and thereby decreases the amount of toxemia. If good results are produced in the colon cases, it is fairly reasonable to assume that some favorable results can be produced in diverticula found higher up in the bowel by the administration of a barium meal. This is particularly applicable in those cases of extreme toxemia where operation is inadvisable.

In all uncomplicated cases where possible, operation should be done. This consists of (a) inversion of the diverticulum into the bowel and covering it over with a line of sutures transverse to the movement of the bowel; (b) an excision of the diverticulum with a careful coaptation of the cut edges in layers, the suture line again being transverse to the long axis of the bowel; (c) in cases where the diverticula are too numerous or too close together or both, an excision of the part of the bowel bearing the diverticula may be performed and an end-to-end or other anastomosis performed.

Of acute complications we have (a) *obstruction*. This may occur in the form of impaction of fæces in the diverticulum, and may extend across the lumen of the bowel. For this all efforts for a liquefaction and freeing of the fæces should be made by colonic flushings. Atropin or lobelia should be given by mouth. Should these methods fail, operation may be essential. Obstruction may also occur because of adhesions following subacute inflammations. These always require surgical intervention, and the earlier it is performed the better it is for the patient.

(b) *Infection and abscess*. These cases require early operative interference. Thorough opening and the institution of drainage are advisable in

DIVERTICULA OF THE JEJUNUM

those cases where the abscess is well walled off and where conditions are too acute to consider excision. On the other hand, the better plan is to excise, if possible, and particularly so if the process is not well walled off. This complication should receive the consideration of a case of appendicitis.

(c) *Perforation and peritonitis.* If acute perforation has occurred it is highly desirable that the abdomen be thoroughly cleaned out and drainage instituted. This presupposes a recovery from the primary shock and a constitutional condition that warrants the administration of a general anæsthetic and the performance of a laparotomy.

CONCLUSIONS

1. Diverticula of the jejunum are rare conditions.
2. They are the forerunners of an ileus and toxemia.
3. They are being diagnosed antemortem, and under careful clinical examination and laboratory tests should be found still more frequently.
4. When found they should be inverted or excised because of conditions, present or potential.
5. Further intensive consideration should be given to the up-building of the patient for the prevention of the future development of diverticula.

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TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting Held March 7, 1921

The President, DR. GEORGE G. ROSS, in the Chair

SUPRAPUBIC SARCOMA

DR. EMORY G. ALEXANDER presented a boy, eleven years of age, who was admitted to the Episcopal Hospital, July 15, 1920, on account of pain in the lower abdomen and inability to void. Two days before admission to the hospital, he jumped down from an elevation a distance of about six or seven feet. Immediately after the jump he had to lie down for several minutes on account of weakness and severe pain in the lower abdomen. In a short time he felt better and was able to walk to his home, a distance of three blocks. A few hours after arriving at home he had a chill, followed by fever and difficulty of urination.

When admitted there was a mass in the lower abdomen resembling a distended bladder: it extended to the umbilicus. The patient was catheterized and three ounces of clear urine was obtained without any diminution in the size of the mass. The bladder was injected with six ounces of sterile water without increasing the size of the mass. After permitting the water to remain in the bladder for a few minutes it was siphoned off and the amount instilled was recovered. On July 17, 1920, a mid-line incision three inches in length was made below the umbilicus. A large organized hæmatoma was found anterior to the bladder. This was evacuated and exposed the bladder. The blood clot was the size of a medium-sized grapefruit and extended well down back of the bladder. The condition resembled very much that of the organizing blood clot often met with in ruptured extra-uterine pregnancy.

The bladder was again distended with water and a leak looked for but none could be found. The clot was extra-peritoneal. The clot cavity was drained by two cigarette drains. The patient left the operating table in good condition.

The convalescence was uncomplicated and the patient was discharged from the hospital on August 2, 1920, two weeks after the operation. At the time of the operation, a culture was taken and some of the clot sent to the laboratory for study. The laboratory report on the culture was "no growth," but on the specimen a "large round-cell sarcoma."

Repeated X-ray studies have been made of the pelvis, spine, chest and femurs with invariably a negative result. An examination by Dr. W. H. MacKinney revealed the prostate hard and much larger than normal, "as large as that of a man's."



FIG. 1.—One of a pair of Levis' separated hooks for fracture of the patella.

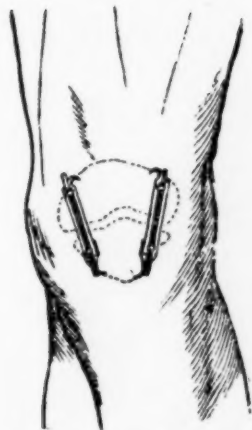


FIG. 2.—Diagram of Levis' patella hooks applied.



FIG. 3.—Case of bony union of patella after treated with Levis' modified Malgaignes hook.

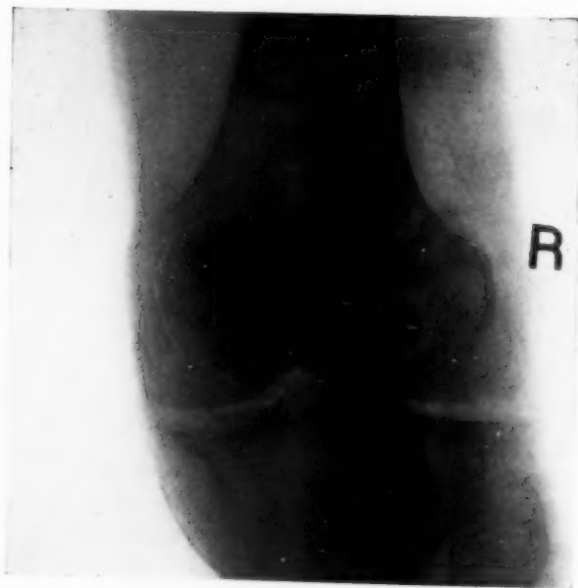


FIG. 4.—J. B. Roberts' case of fracture of patella treated with separated hooks, as used by Dr. R. J. Levis.



FIG. 5.—Patella fracture treated by non-operative dressing followed by short fibrous union.

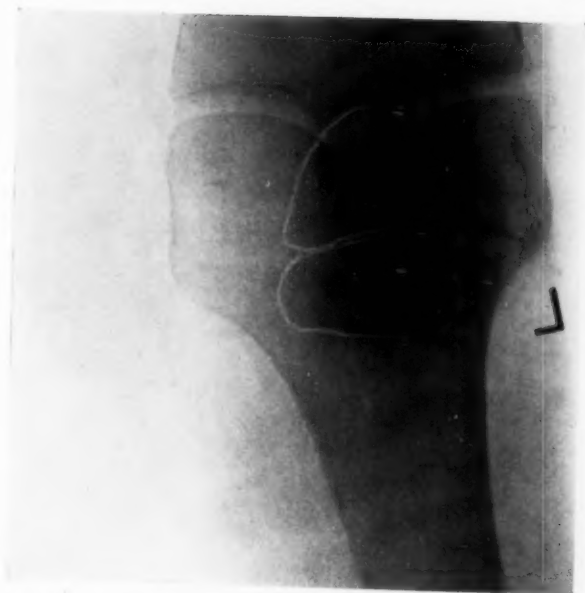


FIG. 6.—Dr. Roberts' case of patella fracture treated without direct fixation.

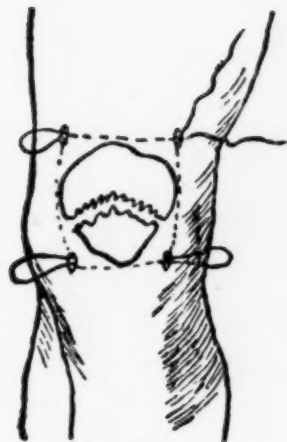
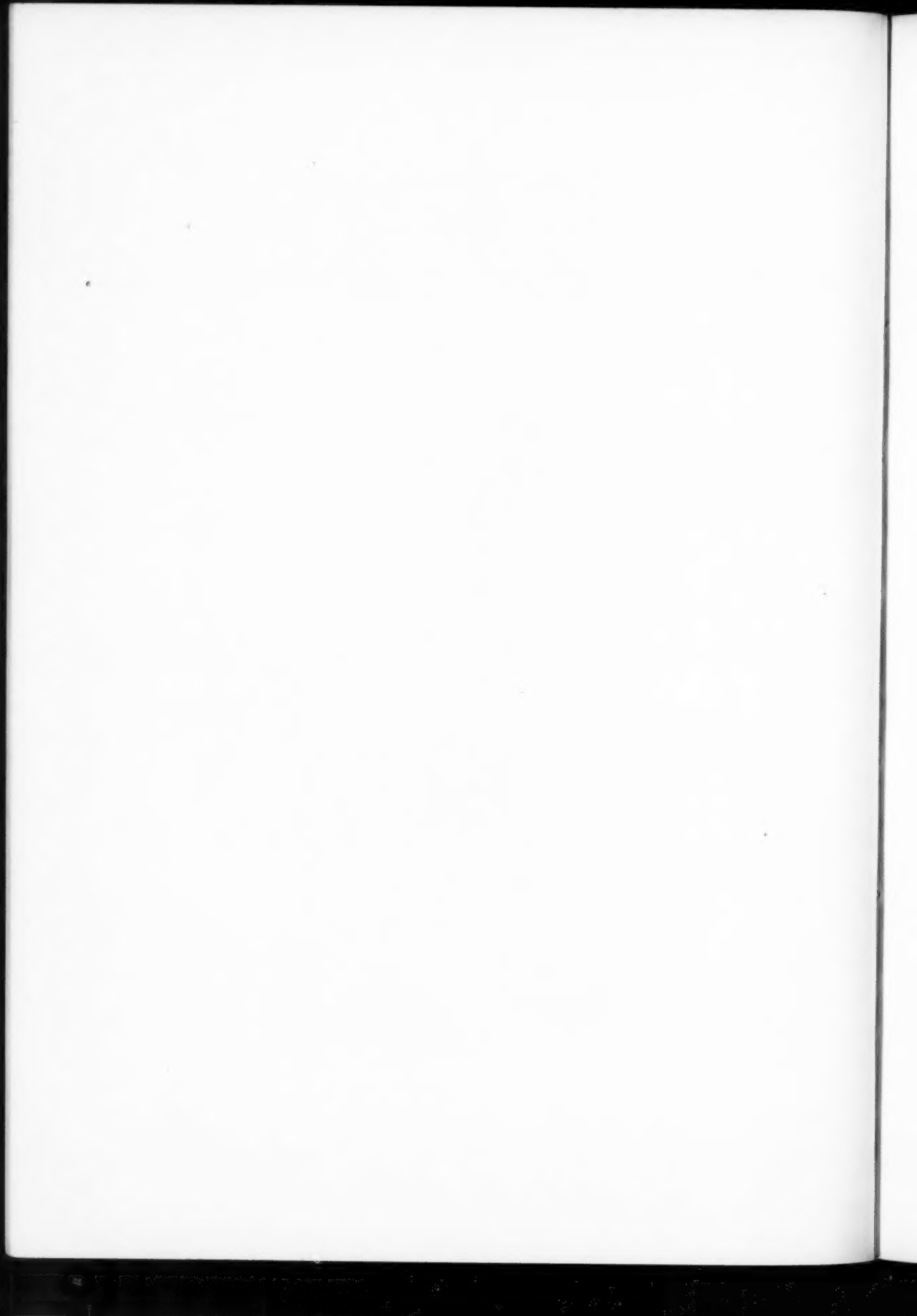


FIG. 7.—Purse string for subcutaneous fixation of fracture of patella.



SUBCUTANEOUS FIXATION OF TRANSVERSE FRACTURE OF PATELLA

The patient remained perfectly well except for asthmatic attacks until February 4, 1921, when the mass suddenly appeared again in the suprapubic region, this time without any chill, fever or urinary disturbance. The patient was again admitted to the Episcopal Hospital on February 4, 1921, when practically the same condition was found as on his first admission.

Careful X-ray, ophthalmological and physical examinations were negative. A complete blood count was as follows: 3,730,000 r.b.c., 7,200 w.b.c., 55 per cent. hg., polymorphonuclear 78 per cent., mononuclear 4 per cent., transitional 6 per cent., lymphocytes 11 per cent., eosinophiles 1 per cent., basophiles 0. The urine was negative except for a trace of albumin, a few leucocytes and an occasional red blood-cell.

Further operative measures were deemed useless and the patient was placed on intensive X-ray treatment. A treatment of one hour was given on February 8, 1921. This was followed by fever, nausea and vomiting, and a rapid diminution in the size of the mass. In three days after the treatment the mass had practically disappeared.

A recent rectal examination shows that the prostate is still slightly enlarged and harder than normal. The induration and enlargement is more marked on the right side, and extending up from the prostate along the wall of the pelvis on that side is a faint cord-like induration.

As to the origin of the growth. Certainly it does not spring from the periosteum or bone. It is possible that it may have originated in the prostate or prostatic sheath. If that should prove true it is quite a rare condition, as only about forty cases of sarcoma of the prostate have been recorded in the literature.

It is quite probable that the origin of the growth was in the immediate vicinity of the hæmatoma and that it sprang from the areolar tissue in the suprapubic region or from the bladder wall.

SUBCUTANEOUS FIXATION OF TRANSVERSE FRACTURE OF THE PATELLA

DR. JOHN B. ROBERTS said that although open operations upon the usual transverse fracture of the patella give a clear understanding of the exact degree of damage to the bone and the enveloping musculo-aponeurotic structures and are followed by cure, they possess a considerable degree of risk to the patient even in the hands of trained surgeons. He had always felt that the septic risk, though small with fully qualified operators and careful aseptic or antiseptic technic, demands that less formidable treatment has a certain degree of plausible advantage. In his early professional days the use of Malgaigne's hook was revived by R. J. Levis and Thos. G. Morton (Figs. 1 and 2), and good results obtained with little risk to the patient, and what was believed to be bony union. He presented skiagrams (Figs. 3 and 4) to prove the value of direct fixation with Levis's separated hooks. He also presented a man, aged fifty-five years, who broke his right patella, in 1886, when thirty-four years old, and was treated by him with Levis's

separated Malgaigne's hooks. Solid bony union was obtained as demonstrated in these skiagrams taken in the winter of 1920 (Figs. 3 and 4).

Eight years later (1894), he broke the left patella, which was treated at the Polyclinic Hospital by Doctor Roberts, with a posterior splint and adhesive plaster. The X-ray plates (Figs. 5 and 6) show close fibrous union with an increased length of bone. The right bone is of good shape, the mobility of the knee-joint perfect, and the scars of the hook points visible in the skin. There must have been originally considerable separation of the fragments in this case or he would not have used the hooks.

The left bone is a little longer than the right and a shallow transverse groove can be felt by palpation. There is also some distortion of the periphery of the left patella. The flexion of the knee is slightly restricted when one attempts to force his left heel strongly towards the buttocks.

This man goes up and down stairs readily and works as a laborer. His left ankle is somewhat distorted because he broke his fibula on that side in 1916. He also has a hammer second toe on that foot. It is apparently these troubles, rather than the fibrous union of the left patella, that now cause him to go down steps a little cautiously. He seemed to save putting full weight on his left foot when he walked up twenty-five or thirty steps and down again.

Doctor Roberts showed the instruments used by Levis himself. They are better than the original Malgaigne instruments, because they can be placed parallel to each other or at any oblique angle.

Doctor Roberts also shows a diagram (FIG. 71.) of the purse-string method of drawing the fragments together in fractures of the patella which are transverse.

This was made some eighteen years ago to illustrate a paper read before the Surgical Section of the American Medical Association. At that time he showed X-ray pictures of experimental fractures brought together by the purse-string method and others of actual results in patients. He does not know who originated the purse-string method, which is good and less dangerous than the suture placed under the patella through the joint.

DR. J. TORRANCE RUGH called attention to the tilting of the fragments as shown in the skiagrams presented. The first cases showed excellent bony union, but a line of cleavage where the fragments were tilted forward by the Malgaigne hooks. To prevent this tilting a careful and accurate closure of the capsule at the lower edge of the two fragments should be made and by avoiding tying the wire or kangaroo suture too tightly.

EPIPHYSIAL SEPARATION UPPER END OF HUMERUS

DR. GEORGE P. MULLER reported the case of S. B., age six, who was admitted to the Misericordiae Hospital, December 20, 1920, having been struck by an automobile. He had sustained an epiphysial separation of the upper end of the right humerus. The arm was apparently reduced and placed in abduction in a Thomas arm splint, but X-ray examination showed no change in the deformity (Figs. 8 and 9), the upper fragment being out-

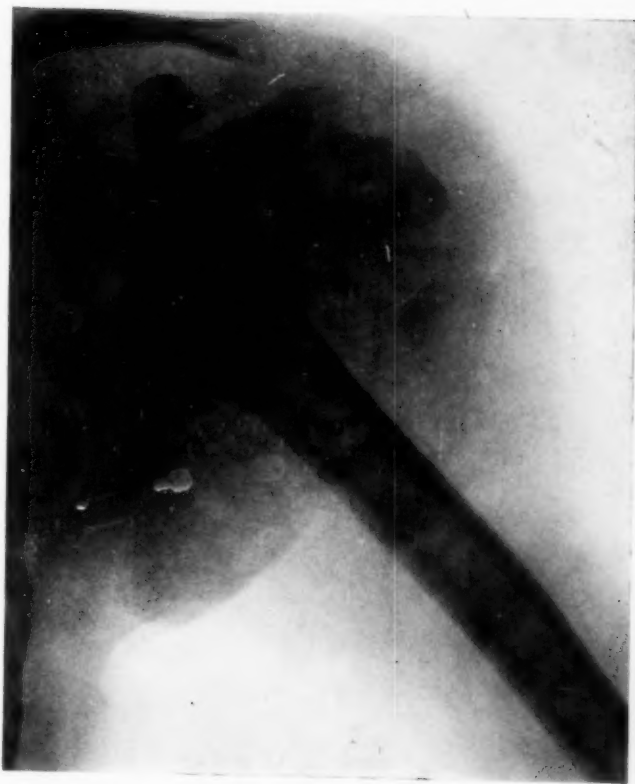


FIG. 8.—Epiphyseal separation upper end of right humerus. Note the deformity.



FIG. 9.—Epiphyseal separation upper end of right humerus.
Note the deformity after abduction.



FIG. 10.—Epiphyseal separation upper end of right humerus. Perfect position after final reduction.

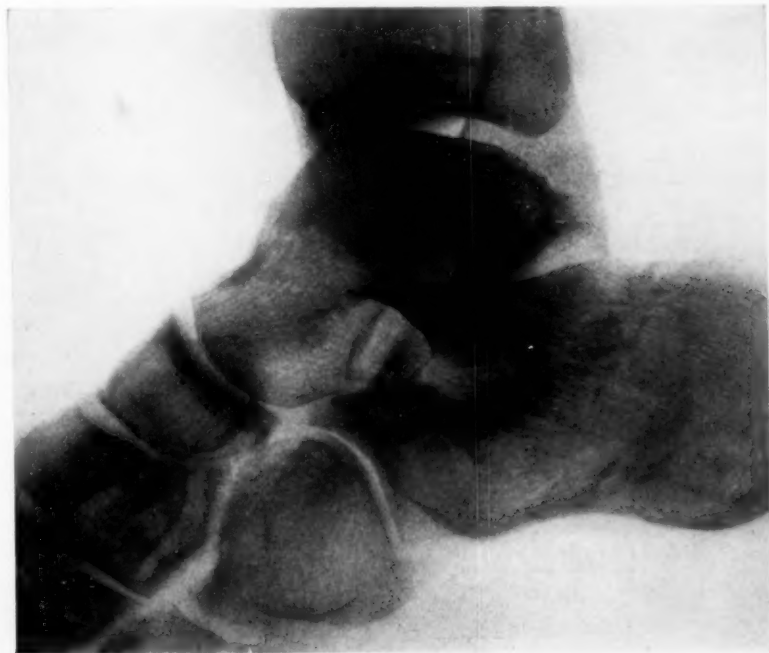


FIG. 11.—Lineal fracture of right os calcis. No deformity.

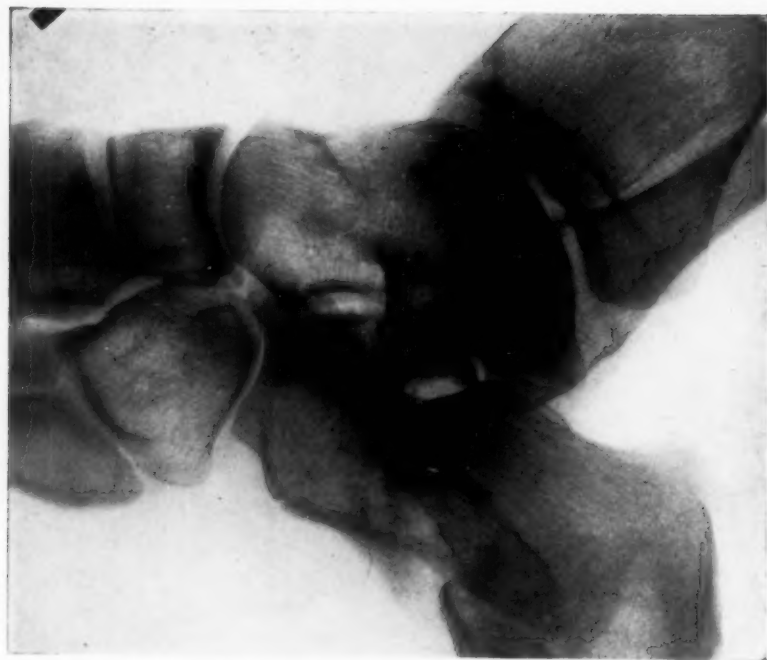


FIG. 12.—Comminuted fracture of left os calcis. Moderate deformity.



FIG. 13.—Impacted fracture upper end of fibula and tibia. Anteroposterior view.

IMPACTED FRACTURE OF THE UPPER END OF THE FIBULA AND TIBIA

ward and the upper end of the lower fragment up under the coracoid process. Under either the fracture was reduced and maintained by the usual dressing for a fracture of the surgical neck (Scudder), (Fig. 10).

The interesting feature of this case was the unusually high deformity and the fact that had the common teaching that abduction be used in treatment, the deformity would have persisted. The importance of checking reduction by X-ray examination can be appreciated.

FRACTURE OF THE OS CALCIS

DOCTOR MULLER also reported the case of W. V., age thirty-three, who fell twenty feet and landed on both heels. He was admitted to the Misericordiae Hospital, November 12, 1920, suffering from severe pain in the feet and in the right sacro-iliac joint. The feet and legs were encased in plaster of Paris. The man has made a good recovery and walks without pain.

He was under the impression that bilateral fracture of the os calcis was rare, but finds that Cahill (*ANNALS OF SURGERY*, 1917, LXVI, 711) in seventy-two cases noted bilateral fracture eight times. In this case one bone (right) showed a lineal fracture practically without displacement (Fig. 11), and the other (left) was comminuted with moderate displacement (Fig. 12). Both Cahill and Cotton (*ANNALS OF SURGERY*, 1916, LXIV, 480) dwell upon the marked disability following this injury. Cotton advises impaction after pulling the heel down with ice tongs.

IMPACTED FRACTURE OF THE UPPER END OF THE FIBULA AND TIBIA

DOCTOR MULLER reported the case of L. C., age fifty, who was injured by being struck by an automobile and admitted to the Medico-Chirurgical Hospital, January 25, 1920. There was swelling, pain and tenderness of the right upper leg and a large hæmatoma in the left thigh. There was an effusion in the right knee-joint. The X-ray revealed a fracture of the upper end of the tibia with slight impaction and of the head of the fibula with considerable impaction (Fig. 13). A plaster case was applied and recovery was uneventful. This unusual fracture seems to offer no opportunity for correction of the deformity except by open operation. This might be indicated where there was marked deformity, but in cases of lesser grade it seems better to avoid manipulation.

DR. J. TORRANCE RUGH said that in these fractures through the body of the os calcis the most troublesome feature in his experience has been the pain which persists. Most of these patients complain of pain for two or three years. Of course, they require some form of support, whether felt or steel pads, or whatever it may be, accurately fitted, but the explanation of that pain which these cases have after this length of time lies in the fact that in this type of bone, bony union does not become solid under one and a half to three years. Bone is thrown out so slowly that the pain is due to the strain upon the fibrous union between the fragments of the part. When bony union is firm and complete there is no further pain.

DR. T. TURNER THOMAS said, in regard to Doctor Muller's case of impacted fracture of the tibia, he had one very much like it last October and was still treating it. In his case there was an outward displacement of the lower fragments on the upper, that is a general outward turn of the leg. The upper end of the tibia was broken into a number of fragments. The fracture was apparently the result of a fall, perhaps on the foot, with a turning outward of the leg carrying the lower fragment outward. He put strong extension on it with counter-extension and with the limbs under strong extension he forced it over as far as it would go in the opposite direction. He got a pretty good reduction of the deformity and maintained it as to epiphysial fracture of the humerus. He had been using in treatment the idea Doctor Muller brought out. Assuming that the fracture was due to abduction pulling strongly on the arm in right angle abduction and forcing the lower fragment out into position by the hand of your assistant the arm was brought down under traction and dressed at the side in the Velpeau position. He figured that the fragments put into position by strong traction and abduction would stay better with the arm kept at the side. New non-operative reduction is difficult. Sometimes he nailed them. Epiphysial separations are more difficult to hold in position after reduction than the pure fractures in older people.

FRACTURE OF THE CALCANEUM

DR. ASTLEY P. C. ASHHURST reported from his service in the Episcopal Hospital, a case of *Malunion of the Calcaneum from Crushing Fracture, Bone Transplantation.*

George E., thirty-nine years of age, was admitted July 6, 1920, with a crush of the left os calcis, sustained in falling from a height of forty feet when scaffolding gave way. There was great swelling of the soft parts, followed by the formation of bullæ, and the originally filthy condition of the skin soon induced suppuration in the blisters thus rendering inadvisable any operation at the time of injury. The deformity was such, however, when compared with the normal foot, that it was not thought proper to leave it permanently uncorrected (Fig. 14).

Accordingly on August 8, 1920, four weeks and a half after the injury, when the condition of the soft parts seemed to promise clean healing of an operative wound, Doctor Ashhurst made an incision 15 cm. in length parallel with the plantar surface, and extending entirely around the posterior surface of the heel from beneath one malleolus to a point beneath the other. The tendon of Achilles was divided by a Z-shaped incision, to permit of its being lengthened about 2.5 cm. when it was again repaired. The upper surface of the calcaneum thus exposed was divided transversely by osteotome from just above the insertion of the tendon of Achilles downward and forward for about 5 cm., and the lower segment of the bone was pried downward toward the sole of the foot, to restore the normal angle with the anterior tarsus. Into the wedge-shaped gap thus made were driven two aperiosteal pegs of bone cut from the subcutaneous surface of the tibia of the same leg (Fig. 15). These pegs measured

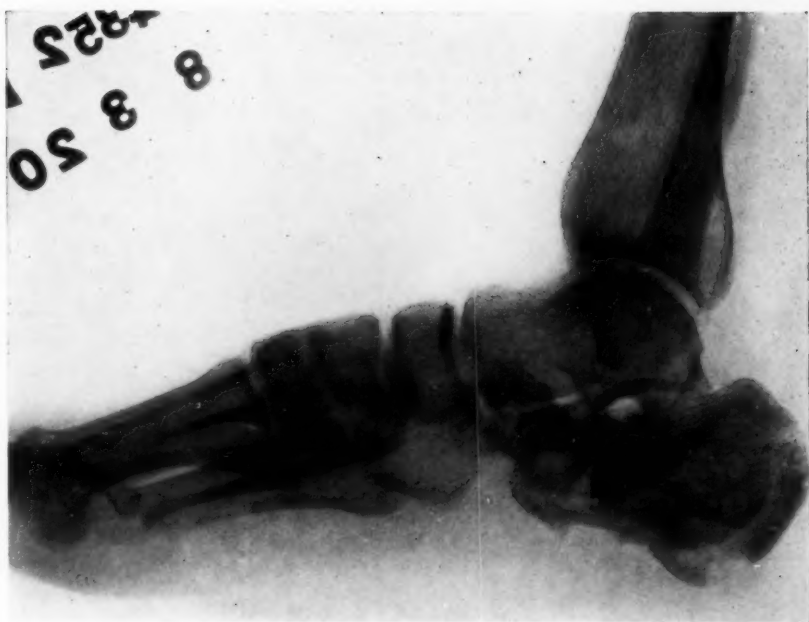


FIG. 14.—Comminuted fracture of l. calcaneum with traumatic flat foot.



FIG. 15.—Two months after bone pegs were inserted. Note bone atrophy from disuse compared with normal foot.



FIG. 16.—Fell from height, landing on ball of feet.



FIG. 17.—After operation (done on third day after injury).

AVULSION OF THE TUBEROSITY OF THE CALCANEUM

about 5 x 1 x 1 cm., and 3 x 1 x 1 cm. The tendon of Achilles, the deep fascia and the skin were closed separately with chromic gut, and a plaster-of-Paris dressing was applied. Nine days later the patient was discharged walking with crutches.

September 14, 1920. Six weeks after operation the patient returned for his first dressing, when the plaster case was removed. There was a small opening in the skin incision through which a small slough of the tendo Achillis, partly detached, could be seen. He was provided with a felt pad in the shoe, under the instep of this foot, and returned to the dispensary for further dressings.

November 3, 1920. Is still attending the dispensary. There is a minute dry sinus at the heel. He says that a few days ago he had "chills and fever" and has been feeling ill since. The leg is red and tender over the wound from which the transplant was taken, though this incision has been firmly healed from the first. He declined to stay in the ward.

November 8, 1920. Readmitted to the ward with an abscess over the upper end of the left tibia, not under the scar of the bone transplant operation, but above it. There is also a red, hot tender area over the lower end of the rectus femoris. The knee-joint is normal.

November 9, 1920. Under nitrous oxide anæsthesia an abscess is opened by an incision along the lateral margin of the quadriceps tendon, and another over the lateral surface of the leg below the knee. Both abscesses contained thick creamy pus, from cultures of which staphylococci were grown. Neither had any connection with the bone.

November 22, 1920. A third, very small abscess on the median side of the thigh opened itself spontaneously. He says he has had abscesses like these over his body once before.

November 24, 1920. Discharged from ward, still using crutches. Abscesses healed.

March 2, 1921. Still uses a cane, but has very little disability. The bony spur on the sole under the point of the heel (a fragment of the original comminution) seems to be rounding off, and a bursa seems to be forming in the plantar tissues over it.

AVULSION OF THE UPPER SURFACE OF THE TUBEROSITY OF THE CALCANEUM BY THE TENDON OF ACHILLES; SCREW FIXATION

DOCTOR ASHHURST also detailed in case of Francis M., fifty-one years of age, was admitted September 14, 1920, with an injury to his left heel. While standing on a coal truck he caught this foot between the body and the spring of the wagon, and had to leap to the ground to keep from falling headlong. He landed on the balls of his feet. Evidently the tendon of Achilles on the left was held so taut by the calf muscles that it tore off the upper surface of the calcaneum as the plantar surface descended to the ground. Though there was very great pain, he was able to walk on the toes of this foot. On admission there was considerable swelling around the heel, but a depression admitting the tips of two fingers could be felt between the plantar surface of

the calcaneum and that part into which the tendon of Achilles was inserted. and the nature of the fracture was confirmed by the X-ray picture (Fig. 16), by Dr. R. S. Bromer.

Three days later, under Esmarch anemia, an incision 15 cm. long was made over the tendon of Achilles down to the lateral margin of the calcaneum, slightly convex to the fibular side. The tendon of Achilles was divided by a Z-shaped incision, to permit it to be lengthened about 3 cm., when it was sutured. The V-shaped interval between the bone fragments was cleared of clot, and while the upper fragment was held in contact with the lower by means of a large hook, two self-boring Lambotte screws were introduced from the superior surface of the upper fragment, ventral to the insertion of the tendon of Achilles. These screws were inserted at different angles so as to bind each other (Fig. 17). The tendon of Achilles, the fascia and the skin were repaired separately with chromic gut, the Esmarch band being removed before closure of the skin. Plaster-of-Paris dressing.

In October the patient developed erysipelas over the shin of the left leg, where was an old scabbed leg ulcer. By the end of October a frank cellulitis had developed, and an abscess was opened on the lateral side of the knee on October 27.

Early in November a cellulitis developed around the operation wound in the heel, which was entirely closed and dry except where a small portion of the tendon of Achilles had sloughed. This cellulitis subsided without further complications, and the patient was discharged December 17, 1920, just three months after operation, with only a small sinus in the heel remaining unhealed

LOCAL TETANUS

DR. K. P. A. TAYLOR, said that the usual phenomenon of tetanus in man is a tonic spasm of the masseter muscle (trismus) with spreading to other muscular groups (descending tetanus). Occasionally the spasm begins in the muscles of the wounded limb and spreads to the body generally (ascending tetanus) or remains confined to the affected limb (local tetanus). He believed the case to be reported to be an example of the latter group.

M. C., a schoolgirl, aged seventeen, fell from a buggy in rapid motion on September 27, 1920. She struck upon her left shoulder and side, with the left arm doubled beneath her. A compound fracture of the lower end of the left humerus resulted. A neighboring physician sutured the skin over the bony ends and reduced and fixed the fracture. Three nights later the left hand became cold and discolored and the patient was brought to the University Hospital.

On admission, the temperature was 102° F. and the pulse 112. The general condition was good. The left arm was swollen and discolored from a point six inches below the shoulder to below the elbow. The hand and forearm were cold and no pulsation was felt in the radial artery. There was an offensive odor. The diagnosis of gangrene incident to traumatism of the brachial artery was made.



FIG. 18.—Contraction of the neck and shoulder muscles simulating opisthotonus.



LOCAL TETANUS

Under nitrous oxide anaesthesia Doctor Muller amputated the left arm about four inches below the shoulder. Short flaps were made, the stump was washed with hot sublimate solution, and Dakin's tubes introduced between the flaps, which were not sutured. Through a miscarriage of instructions, tetanus antitoxin was not given. Culture taken at time of operation yielded *B. Coli communis*.

A good recovery was made. The stump was propped up and the patient voluntarily lay with her head inclined toward the left side, this position giving her the greatest comfort.

On the third day the patient complained of slight pain and stiffness in the neck, which, however, could be straightened voluntarily.

On the tenth day patient complained of "cramps" in the right shoulder, which were quickly relieved by change of position and massage. Patient persisted in keeping her head bent toward the left. On the following day the stump of the left arm was found to be rigid, and there was pleurothotonos toward the left. This was somewhat relaxed by placing patient on her right side (Fig. 18).

This condition remained constant until the thirteenth day, when spasmodic twitching of the stump was observed. These spasms became very painful. The temperature, which had been mounting to 100° F. in the evening, remained unmodified. The pulse, however, had shown a slow and irregular rise from the time of operation, and now averaged 120. Patient seemed nervous and apprehensive, and began to perspire excessively. The probability of tetanus was considered, but with the thought that antitoxin had been administered the diagnosis was held in abeyance.

On the fourteenth day the painful spasms became more intense and more frequent. They occurred almost every half minute, and consisted of a short upward and outward jerk of the stump. A positive diagnosis of tetanus was made. It was furthermore determined that antitoxin had not been administered. There was slight difficulty in mastication but no true trismus. All of the deep tendon reflexes were somewhat exaggerated.

Ten thousand units of antitoxin were given intraspinally, and a like amount intravenously. This was followed by the subcutaneous administration of 5000 units every twelve hours. Large doses of chloral hydrate, chloretone and luminol were used, and a somnolent condition maintained. It was found that luminol alone in doses of 0.1 G. every eight hours was sufficient to maintain the desired state.

On the sixteenth day a second intravenous dose of 10,000 units was given. On the nineteenth day the spasms of the stump became very infrequent, and the general condition was improved, though the patient was very somnolent and perspired excessively. Antitoxin and luminol were stopped on the twenty-second day, and from this time improvement was regular and uneventful. The contracture of the neck and back slowly became released and the patient was discharged on the fortieth day with a healthy granulating stump and in good condition.

A total of 115,000 units of antitoxin was administered, of which 20,000 units were given intravenously, 10,000 intraspinally and the remainder subcutaneously.

Local tetanus was considered a rare occurrence prior to the war, and even some of those so reported were cases of general tetanus with preliminary local manifestations (tetanus ascendens). Thus Demontmerot¹ reported four cases of "parapletic tetanus," of which only one can be properly classified as local tetanus. Axhausen,² in analysis of eleven assumed cases, believed only one to be truly localized. A few single case reports appeared up to the time of the war when the number greatly increased, and among the French caused such interest as to justify the publication of the book on abnormal forms of tetanus by Courtois, Suffit and Giroux.

Etienne³ ascribes the great frequency of local tetanus after war wounds to the fact that the prophylactic injection is able to neutralize the toxin circulating in the blood stream and thus prevent general manifestations. Francaise⁴ states that the antitoxin is not effective in preventing localized tetanus, since it cannot affect the toxin already combined in the nerve or nerves. With these opinions a third French writer, Chauvin,⁵ is in accord, stating that antitoxin either destroys the circulating toxin or renders the blood unable to transport it.

Bruce,⁶ in his tabulation of the 1458 cases of tetanus which occurred in British Home Military Hospitals during the war, states that 201 of these were examples of local tetanus. The ratio of cases of local tetanus to cases of general tetanus tended to become higher each year. He presumes that this was due not only to the introduction of the prophylactic injection of antitoxin, but also to an improvement in the diagnosis of mild and obscure cases. "What in the first years of the war would be considered to be due to a non-specific irritation of nerve and muscle, came afterwards to be recognized as a local manifestation of tetanus." Ashhurst in a recent article points out the similarity between local tetanus and the "experimental" tetanus which had long been observed to follow the injection of relatively non-virulent organisms into the limbs of animals. He ascribes local tetanus to infection by ascent of the toxin along the nerves to the spinal cord, when an arc of increased irritability is established and rigidity and spasm occur. On the other hand, the toxins of a more virulent infection are carried to the spinal cord through the medium of the blood, and affect the shorter nerves supplying the muscles of the neck, the back, mastication, etc.

If we accept the teaching that the toxin of tetanus ascends the motor nerve to the cord, the local muscular spasm of ascending tetanus is due to the involvement of the related segment of the cord. Roughly, the area involved in our case would correspond to the fifth, sixth, seventh, and eighth cervical and first dorsal, as these are the roots reached by toxin ascending the arm nerves (median, ulnar, musculospiral, musculocutaneous, and internal cutaneous). The wide area of spasm—neck, shoulder, and chest—is thus explained. It is difficult to explain why generalization did not occur in this case. The

LOCAL TETANUS

current explanation of local tetanus is that as a result of prophylactic injection only a small amount of free toxin is possible in the blood and lymph, and only such toxin as is introduced by the motor nerves produces an immediate effect. But this patient received no antitoxin as a prophylactic, and we have noted other similar cases in the literature. We may fairly assume that local tetanus developing after prophylactic injection is the degenerate offspring of what would have been an extremely virulent case of generalized tetanus, and local tetanus developing when no prophylactic injection has been given is probably the counterpart of the mild "experimental tetanus."

A word or two about treatment. All methods for administering the antitoxin were used in this case.

Andrewes⁷ questions the value of the intra-theal route in cases of local tetanus. He concurs in the view of French authorities that it is sufficient to maintain, in these cases, the existing protection by subcutaneous doses, but believes that if trismus is superadded intraspinal injection is indicated. The important point is made that an insufficiently treated case of local tetanus may become general as protection becomes weaker. The matter of dosage is of great importance.

In 1915, Irons⁸ condemned the frequently employed method of giving small doses subcutaneously every few hours and gradually increasing the doses as the symptoms advance. She advocated prompt neutralization of all free toxin in the circulatory blood by a large intravenous injection and the neutralization of the toxin already in the central nervous system by intraspinal injection. In the same year Nicoll and Park⁹ also wrote of the value of intraspinal (5000 units) and intravenous (10,000 units) injections at the first treatment. The spinal injection to be repeated in twenty-four hours and 10,000 units to be given subcutaneously three or four days later. Ashhurst,¹⁰ in a late paper, follows this plan with a double dose.

There seems to be considerable divergence of opinion as to whether the intraspinal route affords a means to effect a dissociation between the nerve cells and the toxin molecules. Clinical experiences and the experimental researches of Park and Nicoll, Zolla and Sherrington are in favor of this method. Andrewes⁷ well says that the "fallacy of all reasoning on this matter lies in the fact that there are no secure physiological premises. There is no actual proof that antitoxin can pass from the cerebrospinal fluid into the substance of the central nervous system, nor any proof that it can reach the neurons from the capillaries adjacent to them. There is no proof that, if these things were true, the antitoxin could dissociate from the neurons the toxin which had already entered into combination with them. Many physiologists hold opinions on these points and arguments can be arrayed on either side, but we have not sufficient proof or even consensus of opinion to enable us to reason safely on such a difficult subject as this."

The following cases seem fairly to be examples of localized tetanus as observed before the changed conditions brought on by the great war.

Esau¹¹ in 1909 observed the following case: A boy, aged twelve, received

a large charge of bird-shot and powder in his hand. The following day a liberal excision was performed, and three days later the wound was nearly healed. On the next day there occurred painful contracture of the wrist, and this persisted for eight days, the diagnosis of irritation due to the presence of foreign body being made. Re-operation was performed and twenty more shot removed, with the result that the local manifestation in the hand rapidly became general. Serum was used and recovery reported. The injured hand was the last part to lose its contracture.

Axhausen², reciting the case of Socin (*Kriegschirurgie Erfahrungen*, Leipzig, 1872), declared that a soldier with a flesh wound of the shoulder suffered stiffness of the muscles in the neighborhood of the wound beginning on the forty-eighth day. This was succeeded by some stiffness of the neck and clonic contractures of the shoulder at night. Gradual and complete recovery ensued. No antitoxin.

Jacobsen and Pease¹² described a case of Rixford's as occurring seven days after a perforating wound of the lower lip in a man of fifty, and consisting of localized spasms of the face and neck without trismus. The case was of such a mild nature that the diagnosis was questioned. Serum was used from the second day, with recovery.

Demontmerot¹ reported painful spasms of both legs in a man thirty-five years of age, thirteen days after injury (nature and location of injury not stated). There was slight opisthotonos at times, and dysphagia but no trismus though the patient thought he had had trismus before admission. Recovery followed a single injection of antitoxin.

DR. GEORGE P. MULLER said that this patient was a typical case of traumatic gangrene, black, malodorous, and with a line of demarcation dividing the part which had lost its blood supply. The injury was of the brachial artery just above the elbow. An amputation by transfixion was done and the flaps were left open. A bacteriological examination was made for gas bacilli and none was found, only *bacillus coli communis*. When she first developed symptoms he thought that torticollis had developed. She was perfectly well and smiled and talked of the stiffness of her neck and shoulder. It was only two or three days later that they realized the nature of the trouble. All this time they were under the supposition that antitoxin had been given, and it was only when the details of her care in the ward were discussed that no record could be found of antitoxin injection having been given. The one responsible for giving it stated that he believed he had not given it. Doctor Frazier and Doctor McConnell also thought it was tetanus. As to the treatment. In regard to the use of luminol, last summer in Atlantic City he heard Doctor Dercum talk on epilepsy. He asked him if luminol could be used in conditions of motor convulsions such as tetanus, and he thought it might be very valuable, and so he tried the luminol in this case. The results were quite satisfactory in producing somnolence, not only in this but in a subsequent case in the University Hospital, when the boy was practically asleep during the entire twenty-four hours after they got him under its influence. As to the value of

THE SURGERY OF INFANTILE PARALYSIS

the intraspinal injection the evidence is very conflicting, and it is not possible at the present time to reason clearly that the antitoxin put on the outside of the cord enters the cord itself and fuses with the nerve cell and dissociates the toxin. It seems much more reasonable to believe that the intravenous method would carry antitoxin to the motor cells just as efficiently as does the cerebrospinal fluid with its different specific gravity from the tissue serum. However, one must consider clinical experience, and spinal injection has showed its value and should not be abandoned until someone definitely shows us why it should. War literature shows us nothing; Bruce's statistics show conflicting evidence for and against the intraspinal method of administering antitoxin. He thought probably too much antitoxin was given to this particular patient. If they had been satisfied with one injection in the vein, one in the spinal fluid, and given small doses subcutaneously to further saturate the blood serum, say 50,000 units in all, they might have accomplished just as good results. But it is interesting to study the statistics of Gessner at the Charity Hospital in New Orleans, in which there was very little difference in the series of cases between those who received antitoxin and those who did not receive antitoxin; when tetanus has developed, ordinarily it proceeds with the most startling rapidity and severity and then one realizes the inestimable value of the prophylactic dose. One other point: Hurst in a recent paper on tetanus states that the British Tetanus Committee wrote to a large number of surgeons asking what was their experience with muscular contractions following civil injuries in industrial establishments, and with one exception eighty replied that they did not see them; whereupon it was concluded that muscular contractions following war injuries were due to local tetanus. Hurst believes that some of the cases are of hysterical origin. So the larger number in Bruce's table may upon further study be materially lessened. All writers mention the fact that Courtellement in 1915 was the first to mention local tetanus and that it was a product of the war, but Doctor Taylor searching the literature found several strictly local cases in the pre-war literature.

THE SURGERY OF INFANTILE PARALYSIS

DR. J. TORRANCE RUGH then delivered the annual oration on surgery before the Academy, his theme being "The Surgery of Infantile Paralysis." For this oration see page 61.

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TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting Held March 9, 1921

DR. EUGENE H. POOL, in the Chair

CARCINOMA OF THE THORACIC OESOPHAGUS. SUCCESSFUL RESECTION.

DR. HOWARD LILIENTHAL presented a man thirty-four years old, who exemplified an improved method for entering the posterior mediastinum and for resecting the thoracic portion of the oesophagus. He entered Mt. Sinai Hospital on December 14, 1920. About nine months before there was pain on swallowing solid food. For the past three months he had to wash his meals down with liquid. Oesophagoscopy showed a tumor about 16 cm. from the front teeth, a specimen removed from which was reported by the laboratory at Mt. Sinai to be carcinoma. The blood Wassermann examination was reported as 4 plus. The full extent of the tumor could not be ascertained because of the narrowing of the oesophageal lumen.

More than four years before Dr. Lilienthal had devised the general plan which was carried out in this case.

The operation was undertaken December 16, 1920, under nitrous oxide and ether anaesthesia. The patient was placed on his right side, legs flexed and trunk bowed forward. The bridge was then raised so as to form a scoliosis with the convexity toward the left. An incision was made from a point about one and one-half inches to the left of the spine along the eighth interspace to the mid-axillary line, then downward and then backward along the tenth rib, outlining a long skin flap with its pedicle posterior. This flap was dissected up and laid back. A long incision was now made through the wound area upon the ninth rib, which was resected subperiosteally. Beginning toward the back the pleura was dissected away from the posterior chest wall and then forward away from the under surface of the neighboring ribs, the tenth, eighth, seventh, and sixth being divided. The aorta was easily recognized. The stomach tube was then passed through the mouth and on past the stricture into the stomach. The tumor was finally found as a fusiform swelling which began about one and one-half inches beneath the arch of the aorta and occupied about one and one-half inches of the length of the oesophagus. The oesophagus was isolated and the right pneumogastric nerve was freed from its oesophageal plexus by dividing the branches with scissors so that the nerve lay upon the posterior wall of the chest. The left pneumogastric nerve was not seen. A thin rubber tube was now passed around the oesophagus above the tumor and one below it to act as retractors. The skin flap was placed between the oesophagus and the structures behind it so as to form a partial tube, the cuticular surface next to the oesophagus. The wound was then lightly packed

CARCINOMA OF THE THORACIC OESOPHAGUS SUCCESSFUL RESECTION

with gauze and the dressings held in place by adhesive strips. No shock followed this procedure.

December 30, 1921. Second stage. No anæsthesia, local or general. The patient sat up across the table bending forward. Light adhesions were broken down and a large blunt retractor used to expose the depths of the wound. The oesophagus was drawn toward the surface and the tumor excised with scissors. A T-tube was placed in the oesophagus between the upper and lower segments. The skin flap was in good condition. The wound was lightly packed with gauze and the patient sent to bed in splendid condition. About one and one-half hours later the parts had to be exposed because of hemorrhage, the blood coming from a single small spurter in the wall of the upper section of the oesophagus. It was clamped and although the patient was not in actual danger on account of his hemorrhage it was thought safest to give a transfusion. Therefore 500 c.c. were put in, using the citrate method. From this time on, although there were many little annoying complications, mostly of a mechanical nature, they were overcome one after the other. For a time the patient was fed through an Einhorn tube passed from the mouth across the defect in the oesophagus down into the stomach.

On January 12, 1921, the pedicle of the skin flap was divided at the point where the flap dipped into the chest. It was then dissected off from the interior of the chest and laid in so as to complete the tube of skin. This tube was healed in place, bridging the defect in the oesophagus, but there is still some leakage above and below this bridge. With a very light packing in the wound, however, the patient eats all ordinary food except meat which Dr. Lilienthal has been afraid to give him up to the present time.*

DR. WILLY MEYER said this was the second patient in whom a carcinoma of the thoracic portion of the oesophagus had been successfully removed, this time by the posterior route. It was of particular interest because it proved that in these cases, in which the treatment had been temporarily almost entirely by radium, operative treatment had again come forward.

Personally Dr. Meyer said he felt that the transthoracic route should not be abandoned. It gave free access to any portion of the oesophagus. Subsequent airtight thoracic drainage gave the assurance that an accumulation of infected pleural fluid would not follow and endanger the patient's life. Last year he had seen in such a case done by the transthoracic route and with airtight drainage that the pleural leaves became quickly adherent in the lower portion of the chest, while a pleural effusion persisted further up. He believed such an occurrence could be overcome and the method improved. He further believed that it might be advisable in special cases to combine antethoracic transposition of the proximal stumps of the oesophagus through a wound at the neck with resection of the growth by posterior mediastinotomy, for, after all, reconstructive plastic work on the oesophagus had principally and successfully been done in front of the thorax.

*This method was first described in a preliminary communication before the New York Society for Thoracic Surgery at its meeting of November 23, 1920.

DR. HAROLD NEUHOF described an operation for carcinoma of the œsophagus that he had performed, with the assistance of Dr. James A. McCreery, on a man on the First Surgical Division of Bellevue Hospital, in which the posterior extrapleural route as described by Dr. Lilienthal was employed. An unsuccessful outcome was anticipated, the patient being an alcoholic individual with advanced arteriosclerosis. Dr. NeuhoF reported the operation in order to indicate how adequate the exposure was and its freedom from technical difficulties. After subperiosteal resection of the eighth rib a layer of cleavage was found directly adjacent to the parietal pleura. As a result the recognition of the œsophagus was easy, and its isolation together with the neoplasm simple. The pleural cavity was not penetrated. No attempt was made in the direction of a plastic repair for the œsophagus at the second stage of the operation, performed four or five days later without anæsthesia, in which the œsophagus bearing the tumor was widely resected. Death several days later was apparently due to debility, the wound itself doing well. An additional advantage of the extrapleural route in this case was that the attachment of the perioesophageal tissues about the tumor to the aorta could be readily defined and detached, and the aortic branch entering the tumor could be ligated at its origin from the aorta. By the intrapleural route this case would probably have been considered inoperable because of a supposed cancerous invasion of the aortic wall; certainly the dissection of the tumor-bearing œsophagus from the aorta would not have been as simple.

The question of the repair of the œsophageal defect after removal of a tumor is a secondary matter, as had been pointed out. Dr. NeuhoF had planned to attempt this in his case by a rubber tube, as in the operation for reconstruction of the common bile-duct. His impression was that a tube of granulation tissue would form about the rubber tube to become lined by cells continuous with the œsophageal epithelium, and thus replace the defect. He performed this operation on a dog, and now after four weeks there was apparently complete restitution of the œsophagus. A further report will be made. It was of interest that in all his experiments carried out with Dr. Jerome Ziegler, in which extrapleural resection of the thoracic œsophagus or of the œsophagus in the neck was done in one stage the animals died of suppurative mediastinitis, whereas this did not occur when the operation was carried out in two stages.

DR. FRANZ TOREK said that to his idea this presentation of Dr. Lilienthal's was an epochal event. It gave much encouragement as to the future possibilities of œsophageal surgery. Eight years ago his own case was the only one of œsophageal resection that had been successfully treated. This second case was perhaps the most important. It had seemed possible that the first case was simply chance or luck. Of course every new case was more or less of an experiment and they would still have to learn which was more satisfactory in these cases, an œsophagus of human tissue or one consisting of rubber. Of course if there was no subsequent trouble from stricture, fistula, etc., there could be no question that the one of human tissue was preferable, though the

rubber which never strictured might have some advantages. It was also a question whether the leakage from behind was going to be completely closed; however, he believed there were minor considerations which would surely find a satisfactory solution. To his idea the important thing was that the surgical treatment of carcinoma of the oesophagus had been put on a basis twice as strong as it was some time ago. It would encourage more surgeons to take up the matter, and one or two surgeons could not solve the problem so well as when everybody gives his aid.

So far as the comparative results by surgery and such means as the X-ray and radium were concerned, Dr. Torek thought that every surgeon was of the opinion that radical removal was always preferable to placing entire dependence upon the X-ray or radium. He believed that if a method were discovered whereby the oesophagus became more the property of every surgeon, radium and the X-ray would not be able to compete with it, because removal by the X-ray and radium were uncertain, and the degree of destruction effected was uncertain, while removal by the knife was more accurate. He felt that if there was anything that would cope with surgery it would not be the X-ray or radium but would be a serum.

DR. N. W. GREEN remarked that Dr. Lilienthal's case was most significant. The request for the removal of these growths had been very urgent. Posterior mediastinotomy for approaching the oesophagus had been performed in 1888 by Ivan I. Nassilov (Vratch, Petersburg, No. 25), and Rehn, in 1898, made attempts through the posterior route to extirpate a carcinoma of the oesophagus. Dr. Lilienthal's operation was a clever modification of the posterior route and his way of dealing with the breach in the continuity of the oesophagus was very skillful.

The uncertainty of treatment with X-ray and radium had been mentioned. It was very true that these agents were uncertain. He did not think these growths could be cured often by radium or the X-ray, but he did not think that the results were much more uncertain than the present stage of surgical interference which had now been brought from absolute failure to two successes (the case of Torek and this one of Lilienthal) in hundreds of cases. While this was not a large percentage it showed in which way the advance would be made. By the Lilienthal route he thought it would be made much more rapidly. Dr. Lilienthal's case was of adenocarcinoma of the oesophagus. An adenocarcinoma that stood out in the lumen of the oesophagus was very rare; it had been Dr. Green's experience that epithelioma was more common.

DR. LILIENTHAL, in closing the discussion, said the important point in this method was that it enabled one to get down to the oesophagus safely. He believed, judging from the few cases he had had, that it could be done safely, easily and without shock. If by chance the pleura was opened it could be closed by suture. The procedure enabled one to secure a condition in which there was a mobile oesophagus isolated from the other mediastinal structures with the mediastinum walled off.

Another important point, Dr. Lilkenthal stated, was that this was a general approach to the mediastinum for any work to be done here. He believed tumors of the mediastinum could be operated upon in this way. The important point was not whether a skin tube or a rubber tube should replace the excised œsophagus but that he believed we had a method which would be safe in the hands of the average experienced surgeon. Of course he had tried it in only a few cases, and this was the only one in which the operation had been completed. In the other two cases the tumor was very far advanced, in one case being gangrenous in type. Both of these cases died of mediastinitis. This was an operation that could be done in much less favorable cases than one would suppose. The patient whose case Dr. Neuhof reported was in very poor condition and was going to die shortly any way, so that it was perfectly justifiable to do anything which promised possible relief. His radial pulse was obliterated and his arteries like pipe-stems, yet he got safely enough through to the second stage, and if the œsophagus had not been so bruised and traumatized because of the dense adhesions, the operation might have succeeded. It is possible that this operation can be done under local anæsthesia.

ŒSOPHAGEAL OBSTRUCTION, DUE TO RETENTION OF DENTAL PLATE;
REMOVAL BY GASTRIC ROUTE, 2½ YEARS AFTER SWALLOWING

DR. EDWIN BEER presented a man who was admitted to Bellevue Hospital in January, 1921.

Complaining of inability to swallow solid food, he gave a history of having left his false teeth in his mouth one night on retiring and of having swallowed them. Since that time he had lived on soft food, had suffered from occasional attacks of pain, and had lost 75 pounds.

Radiographic examination showed the plate situated behind the heart well above the diaphragm. The question came up whether the plate could be removed by œsophagoscopy, whether by transthoracic incision, by laparotomy through a gastric incision helped perhaps by œsophagotomy low in the neck. He finally decided against œsophagoscopy because the hooks on the plate which could be readily seen in the X-ray might be firmly embedded in the walls of the œsophagus. It was decided that the transthoracic route would be hazardous, partially because of the greater danger of infection incident to this operation. So finally it was decided to perform a laparotomy and remove the plate transgastrically.

The operation was performed on February 1, through a long left rectus incision. The stomach was fully exposed and no foreign body found in it. The stomach was opened at right angles to the long axis. The whole hand was introduced into the stomach and the cardia located. The location of the cardia was rather difficult because one always felt that it ought to be nearer the left than it is. By introducing two fingers well up, Dr. Beer said he was able to feel the foreign body and to hook his finger into its central part. By manipulation he was able to disengage the hooks that had cut into the œsophagus and by pushing up one side he was able to rotate the plate and thus

MOYNIHAN METHOD OF RESECTION OF STOMACH FOR CARCINOMA

succeeded in bringing one end into the stomach. Subsequently the rest of the plate was delivered. After bringing out the foreign body he found a number of tears in the mucous membrane of the cardiac orifice caused by delivery of the plate. The stomach was closed by mattress sutures and a gastrostomy, of the Witzel type, at right angles to the gastric incision. In the after-treatment the foot of the bed was raised. There was no febrile reaction. Fluid was administered by rectum and hypodermoclysis, and on the fifth day food was given by mouth. This he took well and on the eighth day the tube was removed and he was able to take food normally. It is now just one month since the operation and the patient has made a satisfactory recovery.

DEFORMITY OF HAND—FORMATION OF A NEW THUMB FROM THE STUMP OF THE FIRST METACARPAL

DR. HENRY H. M. LYLE presented a boy ten years old, who six years ago had his right hand badly burned. The original injury destroyed the whole of the thumb, with the exception of the proximal end of the first metacarpal, the whole of the little finger, and the two terminal phalanges of the index finger. The resulting contractures left a useless hand, the hand being represented by a club of useless cicatricial tissue. This hand presented three problems, viz.: The cure of the contractures, the formation of a new thumb, and the development of the wasted muscles. The first stage consisted of the removal of the scar tissue from the hand, and the transfer of a flap from the abdomen to cover the defect. The second stage consisted in the formation of a new thumb from the nubbin of the first metacarpal. The first metacarpal differs from other metacarpals in having a wide and varied range of motion. From a surgical viewpoint we can consider it as a phalanx. Advantage of this anatomical fact was taken by Huguier in the development of his operation. A modification of his operation has made a useful stump out of an apparently useless stub of a metacarpal. There are no longitudinal scars on the palmar, or on the finger. In transferring the skin flaps from the abdomen, every endeavor was made to have the suture lines run parallel to the creases of the hand. The usual massage and hydrotherapeutic measures were employed. One must not depend on these alone, but must stimulate the patient to active use of the disused member. He swings Indian clubs, drives nails, writes his name, and last but not least, he can pick up individual playing cards with his new thumb.

DR. BURTON JAMES LEE called attention to an operation for hand deformity by Delrez, of Belgium. With a hand injury with the phalanges of the thumb destroyed and those of the index finger badly injured, the operation consisted in the removal of the normal second metacarpal bone, thus allowing for the use of the first metacarpal for an effective grip. The patients thus treated had a fairly useful hand with good control of objects held.

MOYNIHAN METHOD OF RESECTION OF STOMACH FOR CARCINOMA

DR. JOHN DOUGLAS presented a man who was admitted to St. Luke's Hospital on November 1 of last year. He gave a history of symptoms extend-

ing over a period of five months, chiefly those of indigestion and of a mass noticed five weeks before admission. The stomach contents showed an absence of free HCl and the presence of lactic acid and blood. The X-ray showed carcinoma of the pylorus. There was only a moderate involvement of the glands. There was a retention of five hours.

Two or three weeks before this patient came under his observation, Dr. Douglas said he had heard Sir Berkeley Moynihan describe his method of stomach resection over which he was very enthusiastic, and as this man was in good condition, did not show a very large retention, and was not much emaciated, he thought him a suitable case in which to try Sir Berkeley Moynihan's method. The first step in this operation was like that of any ordinary resection of the pyloric end of the stomach. After removing the pyloric end of the stomach bearing the carcinoma, instead of doing the ordinary Polya-Balfour operation, bringing up a loop of jejunum 14 inches from the duodeno-jejunal junction, a point on the jejunum 8 to 10 inches from the duodeno-jejunal junction was selected. The jejunum was here divided, its proximal end clamped and distal end closed by inversion sutures. The portion of the jejunum is then brought up either ante-copically or retro-copically and anastomosed to the remaining portion of the stomach. In this instance Dr. Douglas brought the jejunum up retro-coelically and did a lateral anastomosis with the remaining portion of the stomach, as in the Polya-Balfour operation. The clamp was then removed from the proximal portion of the jejunum and it was implanted laterally into the jejunum below the mesocolon.

X-ray examination immediately following the operation, at the end of three weeks, and at the end of three months after the operation showed a stomach functioning well and tending to assume a normal contour. The advantages of the Moynihan operation over the Polya, Dr. Douglas said, were that it did away with the long loop of jejunum and thus prevented the danger of kinking or sagging, or stasis in the loop, and restored the first portion of the gastrointestinal tract to something more closely approximating a normal physiological and anatomical condition. The disadvantages of this operation were that it required a longer time to perform it than did the Polya-Balfour operation. It was a more difficult operation and required more suturing than the Polya-Balfour operation. If one had a patient in a very serious condition, one who was a poor surgical risk, Dr. Douglas said he would not advise this operation. It had another disadvantage in that there were more raw surfaces than in the operations usually done and required more care in order to carry it out with strict asepsis. This patient had had a wound infection and still had a hernia.

Dr. Douglas stated that he had presented the case to bring out discussion and to find out whether others had tried this method, also to ascertain whether it was an operation that should be done.

The patient was doing well, had gained 35 pounds, had no gastric distress at any time. Sir Berkeley Moynihan advocated this procedure for all gastric

DIVERTICULUM OF THE ŒSOPHAGUS

ulcers except very large gastric ulcers adherent to the liver; he thought it should be done in all other cases of ulcer of the stomach.

DR. A. O. WHIPPLE spoke of the findings at autopsy following the Polya-Balfour and the Moynihan operations. He had had two cases, one following the Polya and one the Moynihan operation, in which the patients died of post-operative pneumonia. In the case in which the Polya operation had been performed there was a distinct angulation where the part brought up was anastomosed to the stomach. In two other cases recovered that he had seen there was a tendency to some degree of retention following the Polya operation. In the man who died of post-operative pneumonia following the Moynihan operation the way in which the viscera lay furnished a striking argument in favor of the Moynihan operation. There was in this case no retention; the result was much better from the physiological standpoint and from the standpoint of appearance and position of the viscera than when the Polya method was employed.

DR. DOUGLAS said there was nothing to add except that anatomically and physiologically he believed the Moynihan operation was a good one, but he did not think it should be attempted in a patient in whom the margin of safety was small and the patient a poor operative risk, as it required more time as more suturing had to be done in the operation.

DIVERTICULUM OF THE ŒSOPHAGUS

DR. FRANZ TOREK presented a woman who had suffered from dysphagia for more than six years. She had the usual symptoms, regurgitation of food and gurgling sounds in the neck on swallowing. She had also lost some flesh.

A bougie introduced into the œsophagus was halted at 16 cm. from the teeth. The röntgenogram revealed a pouch posterior to the œsophagus, its mouth at the level of the sixth cervical vertebra and its vertical diameter corresponding to the combined height of the sixth and seventh cervical vertebra, about 4 cm.

The operation was performed on January 13, 1921. Incision at the anterior border of the left sterno-cleido-mastoid muscle through skin, platysma, and superficial fascia of the neck. The sterno-cleido-mastoid was retracted outward, the sterno-hyoid inward. The omo-hyoid was divided. The middle cervical fascia was then divided at the anterior border of the carotid sheath, allowing the vessels to be retracted outward and the thyroid gland inward. The inferior thyroid artery, which is usually divided in the operation of external œsophagotomy, was not encountered.

The œsophagus was exposed at its posterior aspect where it is in relation with the vertebral column. There a small pouch about 2 cm. in diameter was found and was separated from the surrounding connective tissue, a gently compressing dull clamp being used to hold it. An œsophageal bougie, now introduced through the mouth in order to demonstrate the relation of the pouch to the œsophagus, did not enter the diverticulum but passed easily down the œsophagus, evidently because the pouch was being drawn out

laterally. The introduction of the bougie caused gagging on the part of the patient who thereby blew up her diverticulum with air, causing the sac to be inflated to almost twice the size it had in the collapsed state.

The variation in the size of one and the same diverticulum is of some interest. While at operation the size of the sac was smaller than that shown in the picture, the fluoroscopic examination revealed a sac easily twice the size of the one in the röntgenogram, as stated by Dr. Stewart who made the examination. When the picture was taken the sac had already largely emptied itself. Like a hernial sac, therefore, the size of a diverticulum varies in accordance with its contents. After thorough separation of the sac from the surrounding tissues a fine ligature of chromicized catgut was tied around the rather broad neck. Before cutting of the sac two silk sutures were carried through the muscularis, one above the sac, the other below. After removal of the sac and searing of its stump with an electric cautery, these two sutures were tied and three or four more were inserted between them to close the muscular coat over the stump. A rubber tissue drain was introduced to the site of the suture. The sterno-cleido-mastoid muscle was sutured to the sterno-hyoid with fine chromic gut. The platysma was sutured with fine chromic gut, the skin with silkworm gut.

For three days the patient received water and food by the rectum. On January 16 she was allowed to swallow. There was no leakage at this nor at any other time. On the seventh day, when the sutures were removed, the wound had closed. At present a large bougie, No. 40, easily passes down. Swallowing is perfectly normal.

In this case general anaesthesia was induced. In one case Dr. Torek performed the operation under local anaesthesia which proved perfectly satisfactory except in the depth, at the vertebral column, where there was a slight amount of pain. Unless counterindicated, he gives preference to general anaesthesia.

BENIGN STENOSIS OF THE OESOPHAGUS

DR. NATHAN W. GREEN presented two cases in connection with his paper on this subject, for which see page 724, LXXIII, June, 1921.

DR. WILLY MEYER wished to say a word in regard to the Abbe string method for dilating a stricture of the oesophagus. At the second meeting of the American Association for Thoracic Surgery in 1919, Dr. Plummer of Rochester, Minn., spoke of more than 100 cases of oesophageal stricture treated by gradual dilatation in none of which gastrostomy had been done.

Many years ago when the old type of bathtubs was in common use, caustic lye was used for cleansing and quite a number of children swallowed accidentally this lye and developed a cicatricial stricture of the oesophagus. This was along in the eighties and nineties of the last century when the oesophagoscope and bronchoscope and other methods of passing a sound had not as yet been introduced. But they did very well with these cases. They had to do a gastrostomy, and the next step was to pass a string from above downward.

STRICTURE OF THE ŒSOPHAGUS

A discussion of this subject would not be complete without mentioning the excellent work done by Theodore Dunham of this city. He was the first to teach us how the thread could best be swallowed. It then had to be gotten from the gastric fistula. This thread acted as a guide in the further treatment. It was left loose and long and stayed in place. By means of Dr. Abbe's string method the stricture was then cut and gradually stretched. The results were good.

Dr. Meyer said he had used this string method also in external urethrotomies where there was marked cicatricial stricture of the bulbous portion of the urethra. The string does not cause bleeding. After the stricture had been widened large sounds could be passed, and the results were very good.

Since the title of Dr. Green's paper had been announced Dr. Meyer said he had not had the time to follow up his cases, operated by the string method. He believed these patients should continue to come back regularly to the man who had operated upon them and who could pass a sound, if necessary. He had watched with interest the literature on this subject. It seemed that foreign colleagues were not much using this string method. Lately he had read of a collection of 14 cases of ante-thoracic œsophagoplasty that had been done for cicatricial stricture. Here we had often succeeded in stretching the strictured œsophagus, which, in his opinion, should first be tried.

Dr. Green stated that he thought the Abbe string method was the method of choice in the longer strictures of the œsophagus. If one could get these cases earlier the tax on the surgeon would be diminished. If one got them at their source, nearer the time when the lye was taken, they would be easier to cure. A gastrostomy of the Senn-Kader type should close up of itself. If one recalled the work on dogs it would be remembered that a gastric fistula could not be kept open unless something was put in to keep it open. In most of the cases which he had experienced the fistulæ had closed of themselves unless they were kept open with a tube.

STRICTURE OF THE ŒSOPHAGUS

DR. TOREK presented a specimen from a child two years old. The patient had come under his treatment on December 1, 1919. After having swallowed lye thirteen months previous to that time, he developed acute symptoms which lasted three weeks. Then there followed an interval of fairly good health for three months, after which dysphagia set in, the food being regurgitated as soon as it was swallowed. He was able to swallow fluids if taken cautiously.

At an examination by Dr. Torek with the aid of silk web elastic bougies a No. 16 was made to pass, with some difficulty, through a stricture about four and one-half or five inches from the teeth but failed to pass through one a couple of inches farther down.

Knowing of the instruments constructed by Dr. Armistead Crump for the purpose of dilating strictures, Dr. Torek decided to employ them in this case and to request Dr. Crump to introduce the same. The instruments which were shown were of flexible metal. A fine, long stricture searcher probe was

inserted in a tunneled container, the same as a trocar was contained in a canula. The two were introduced together until the point of the instrument impinged upon an obstruction, usually the mucous membrane wall of a sacculatation above the stricture. Then the canula and probe were retracted slightly, after which the canula was steadied, while the filiform probe, which had previously been given a bend at the tip, was pushed forward. By a twirling motion imparted to the probe the opening of the stricture was located and the filiform was introduced. No force was employed in this procedure. At a distance from the tip of the wire there was a minute olive-shaped enlargement which was also introduced through the stricture. On this wire as a guide olives of different sizes mounted on a flexible staff were threaded and carried down until they struck the small olive on the filiform.

In this way the dilatation was made up to No. 27 on December 20. Then there was a lapse of two months during which the child had measles, otitis media, and a double mastoid operation, and manifested such a general decline that a transfusion of blood was given. On February 22, 1920, the dilatation was resumed, and a No. 22 passed the stricture. By March 10 the dilatation had gone up to No. 34. On March 20, after a No. 34 had been introduced, a röntgenogram with a bismuth-filled sausage skin in the oesophagus was taken. After the patient returned to the ward he was rather sleepy and also vomited some mucus and dark blood-stained fluid. At night he was semi-conscious, sleeping most of the time, and his temperature rose to 102.2. On the following morning the patient died. On the left side of his chest a subcutaneous emphysema over an area of five by six inches was found.

At autopsy there were found two strictures, the upper one well dilated and in good condition; the lower one also well dilated, but within its confines there was a small ulcer. This ulcer represented the outlet of a narrow sinus which led to a thickened mass containing some pus and perforating into the mediastinum—evidently an old process. The smallness of this sinus gave evidence that it could not have given access to one of the large bougies that had been introduced. The lungs showed congestion which was characterized as a beginning pneumonia. There was no perforation of the lungs or bronchial tree. The larynx unfortunately was not seen at autopsy. A lesion there might have satisfactorily explained the presence of the subcutaneous emphysema. Death was probably due to pneumonia, possibly to the old peri-oesophageal infection.

CORRESPONDENCE

THE EFFICIENT TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR

EDITOR, ANNALS OF SURGERY:

Sir:

The paper in the June number of the ANNALS OF SURGERY entitled "Results of the Treatment of Twenty Recent Cases of Intracapsular Fracture of the Femur by Abduction and Plaster Fixation" is a novel contribution to the literature of the subject, because it reports a series of twenty consecutive cases in which efficient treatment was applied regardless of age, or physical condition. Eighteen of the patients were from sixty to eighty years of age; in five there was incontinence of urine and feces, and in six bed sores were present; yet but two of the patients died, one, eighty years of age, semi-conscious on admission, and the other suffering from cardiorenal disease. With these exceptions the physical condition of the patients improved under treatment.

As to the results, it is stated that in eight full function was restored, in nine there was but slight impairment of function, and only five used canes in locomotion. In other words, the results were satisfactory in seventeen of the eighteen patients treated.

This report adds to the now rapidly accumulating evidence in support of my contention, that in the great majority of cases efficient treatment is not only practicable, but is actually more conservative from the life saving standpoint than the neglect of the local injury in the supposed interest of the patient.

Furthermore, that the results because of the mechanical and nutritive obstacles to repair, are more directly determined by favorable opportunity than are those of any other fracture.

These conclusions are opposed to accepted teaching because, being adapted to inadequate mechanics, it is chiefly concerned with explanations of failure on other grounds than the obvious lack of opportunity for repair. This teaching is now the chief obstacle to progress because by upholding the irresponsibility of the surgeon for the result, it encourages the inefficiency and neglect that have always characterized the conventional treatment of the most disabling fractures. The abduction method is adequate in competent hands, to assure the opportunity for functional repair, and for this opportunity which is the primary essential of success, the surgeon should be held responsible.

With certain theoretical conclusions in the paper I cannot agree. It is stated by the writers that the X-ray pictures taken on removal of the

CORRESPONDENCE

plaster splints showed dense fibrous union, although clinically it would appear that bony repair was present; and that "osseous union is not to be expected after sixty-five years of age."

The completion of bony union after central fracture is a slow process, and the continuity of the trabeculae passing from one fragment to the other, may not become evident for many months; consequently the character of the union cannot usually be determined by X-ray examination so soon after the injury. "Full function," as I interpret it, requires the firm resistance that solid union alone can assure.

I am convinced that there is no age limit for repair, even in central fractures. In one case under my care bony union was attained in a patient eighty-nine years of age, and such union is a commonplace in patients far past the limit set by the writers.

It may be noted also, that although the fracture was classed as intra-capsular in all of the cases reported in the paper, it is now fairly established that fracture at the base is the more common type even in elderly subjects, so that prospects of union from the nutritive standpoint is far better than has been supposed.

Speculation on the exact nature of repair are of slight importance, however, compared with the fact that twenty patients, with but two exceptions of advanced age, of a type usually considered as subjects for life saving neglect, were efficiently treated for intracapsular fracture of the neck of the femur with but two deaths, and with restoration of satisfactory function in all but one instance.

Very truly yours,

ROYAL WHITMAN.

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